/93

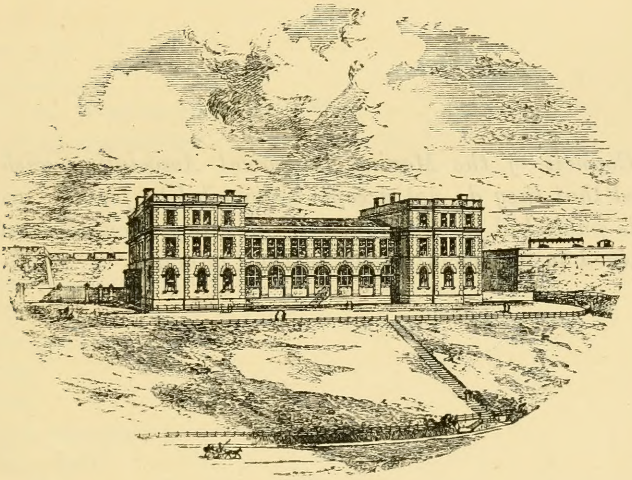
Journal

OF THE

MARINE BIOLOGICAL ASSOCIATION

OF

THE UNITED KINGDOM.



THE PLYMOUTH LABORATORY.

VOLUME II (N.S.)

1891—92.

PLYMOUTH:

PUBLISHED BY THE ASSOCIATION.

Agents in London :—Messrs. DULAU & Co., 37, Soho Square, W.

The Council of the Marine Biological Association wish it to be understood that they do not accept responsibility for the accuracy of statements published in this Journal, excepting when those statements are contained in an official report of the Council.

2677

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CONTENTS OF VOLUME II.

(NEW SERIES.)

ERRATA.

Page 17, line 25, *for* 6 lbs. *read* 2 lbs.

„ 58, line 8 from bottom, *for* p. 64 *read* p. 67.

„ 67, line 5 from bottom, *for* p. 55 *read* p. 58.

„ 121, line 23, *for* it posterior *read* its posterior.

„ „ line 10 from bottom, *for* growth *read* fourth.

„ 190, lines 4 and 8 from bottom, *for* Ammastrephes *read* Ommastrephes.

„ 230, bottom line, for *scobrus* read *scomber*.

„ 282, line 16 from bottom, *for* 30 to 50 fathoms cable *read* 30 to 50 fathoms ca. (circa).

„ 334, line 12 from bottom, for *coronata* read *verrucosa* (= *gemmacea*).

„ 335, line 13, for *ciliata* read *cæca*.

„ 342, line 14, *for* IRENE VIRIDULA, *Eschsch. read* LAODICE CRUCIATA, *Ag.*

„ 374, line 8 from bottom, *for* (S. minuta) *read* (S. lutea).

„ 400, line 11, *for* (R. bevis) *read* (R. lævis).

ADDENDUM.

Page 402. *Rhombus maximus.*—It should have been mentioned that the metamorphosing examples taken at the surface are of an olive-brown colour, profusely speckled with large, black, stellate chromatophores.

COMPARATIVE TABLE OF INCOME AND EXPENDITURE.

1892-3 and 1893-4.

Comparative Table of Income and

	Income of 1892–3. £ s. d.	Income of 1893–4. £ s. d.	Increase. £ s. d.	Decrease. £ s. d.
H. M. Treasury	1000 0 0	1000 0 0		
Fishmongers' Company	400 0 0	400 0 0		
,, ,, Donation	......	105 0 0	105 0 0	
Drapers' Company ,,	......	105 0 0	105 0 0	
Mr. Thomasson's ,,	250 0 8	......	......	250 0 8
Composition Fees	16 5 6	15 15 0	......	0 10 6
Annual Subscriptions	160 12 0	178 10 0	17 18 0	
Rent of Tables	34 0 0	36 16 3	2 16 3	
Sale of Specimens	205 16 9	197 9 1	......	8 7 8
,, Journal	20 6 1	14 1 4	......	6 4 9
,, Monograph	6 15 7	6 10 0	......	0 5 7
Admission to Tank Room	70 0 10	77 16 6	7 15 8	
Interest on Investment	35 2 0	34 19 10	......	0 2 2
Investment sold	......	303 7 3	303 7 3	
	2198 19 5	2475 5 3	541 17 2	265 11 4
Increase...	276 5 10	......	265 11 4	Deduct decrease.
	2475 5 3	2475 5 3	276 5 10	
Ordinary Receipts	1948 18 9	1961 18 0	12 19 3	
Extraordinary Receipts	250 0 8	513 7 3	263 6 7	
	2198 19 5	2475 5 3	276 5 10	

	£ s. d.
Total Receipts in 1893–4	£2475 5 3
Total Payments in 1893–4	2268 10 2
Receipts over Payments	206 15 1

Dr. *Cash.*

	£ s. d.
To Receipts from 1st June, 1893, to 31st May, 1894	2475 5 3
	2475 5 3

EXPENDITURE, 1892–3 AND 1893–4.

	Expenditure of 1892–3. £ s. d.	Expenditure of 1893–4. £ s. d.	Increase. £ s. d.	Decrease. £ s. d.
Salaries and Wages	1223 0 4	1263 7 0	40 6 8	
Stationery, Printing, Postage, &c.	138 10 0	168 3 6	29 13 6	
Printing and Illustrating Journal	106 1 4	85 14 9	......	20 6 7
Purchase of Steam Launch ...	290 13 2	....	......	290 13 2
Gas, Water, Coal, Oil, &c. ...	110 14 5	107 10 5	......	3 4 0
Coal and Water for Steam Launch	36 3 2	22 5 3	......	13 17 11
Stocking Tanks and Feeding .	72 6 5	90 17 4	18 10 11	
Glass, Chemicals, Apparatus, &c.	127 0 0	123 9 2	......	3 10 10
Maintenance and Repairs of Building and Boats	123 2 10	131 13 0	8 10 2	
Rates and Taxes..................	26 10 6	34 12 3	8 1 9	
Boat Hire..........................	33 15 6	41 8 10	7 13 4	
Travelling	57 8 1	42 5 5	......	15 2 8
Expenses of Exhibition of Specimens	......	59 7 10	59 7 10	
Library..............................	45 14 3	21 3 4	......	24 10 11
North Sea Investigation	90 13 1	76 12 1	......	14 1 0
Immature Fish Investigation.	20 0 0	......	......	20 0 0
Labrador Investigation.........	0 16 6	......	......	0 16 6
	2502 9 7	2268 10 2	172 4 2	406 3 7
Deduct total decrease	233 19 5	......	Deduct increase	172 4 2
	2268 10 2	2268 10 2	Total decrease	233 19 5
Ordinary payments	2190 19 11	2209 2 4	18 2 5	
Extraordinary payments	311 9 8	59 7 10	Deduct increase	252 1 10
	2502 9 7	2268 10 2	Total decrease	233 19 5

Contra. *Cr.*

	£ s. d.
By Balance from May 31st, 1893, being amount overdrawn at Bankers, less Cash in hand	196 13 8
By Payments made from June 1st, 1893, to May 31st, 1894................	2268 10 2
By Balance carried forward to June 1st, 1894	10 1 5
	2475 5 3

Assets of the Association on May 31st, 1894.

				£	s.	d.
Property in Plymouth :						
Laboratory Building, with Sea-water Reservoirs, Tunnel to Rocks, &c.				6825	0	0
Gas Engines, Pumps, Machinery, Furniture, Utensils, Bottles, &c.				1218	5	4
Tanks, Heating Apparatus, Pipes, Fixtures, and Fittings				2148	14	6
Books and Pamphlets				1042	16	11
Animals in the Tanks				30	0	0
Preserved Specimens Unsold (Including Value of Bottles)				117	10	5
Preserved Specimens in Museum				16	6	10
Unsold Publications				174	12	6
Chemicals (including Value of Bottles)				45	7	10
Steam-launches, Boats, Fishing Gear				173	8	0
Arrears considered good :—	£	s.	d.			
Subscriptions	25	4	0			
Specimen Sales	26	8	2			
				51	12	2
Property in London :—						
Value of £670 Forth Bridge Railway 4 per cent. Guaranteed Stock				837	10	0
Unsold Publications (Messrs. Dulau and Co.)				71	15	6
Exhibition Series and Accessories				60	0	0
Cash in hand and with Robarts, Lubbock and Co.				10	1	5
Total				£12,823	1	5

Journal of the Marine Biological Association.

Director's Report.

In accordance with a resolution of Council, I entered on my duties as Director on the 29th of November last.

On December 16th, Mr. Garstang, who had acted as assistant since the opening of the Laboratory, intimated that he had been successful in obtaining the Berkeley Fellowship at Owens College, and would require to take up his residence in Manchester at the commencement of the Winter term. Mr. Garstang left on the 30th of December, and on the 24th of January, his successor, Mr. H. N. Dickson, F.R.S.E., F.R.M.S., arrived.

Mr. Dickson is a physicist rather than a biologist, and has been identified for some years with the Scottish Meteorological Society, Ben Nevis Observatory, and the Challenger Office. In securing his services I desired to broaden the Association's range of observation by combining this branch of science with the biological work already in progress. In all questions concerning movements, migrations, and spawning of fishes, as well as the movements of their food, I am convinced that both the temperature and currents of the sea must be considered, and that a thorough knowledge cannot be obtained except by the combination of biological and physical observations.

The Council having signified its approval, physical work having in fact been a part of the original design of the Association, a scheme of work has been organised with the hope of eventually obtaining some valuable results in practical fishery questions. Observations will be taken systematically in the Channel, and in the harbours and estuaries in the neighbourhood, with the view of following changes in temperature and density at different seasons of the year and in different years. These observations will be discussed in relation to what fishery statistics are available. Efforts are also

being made to interest fishermen in the subject, and to set them to make observations of surface temperature on the fishing grounds.

Besides practical work, Mr. Dickson hopes to deal with material already in existence. Through the courtesy of the Meteorological Council, access has been obtained to the extensive records of sea temperatures in the Meteorological Office. The Council were kind enough to instruct their Secretary, Mr. R. H. Scott, F.R.S., to render all possible assistance in the work, and a large number of documents have already reached Plymouth for criticism and discussion. It is hoped that the changes of temperature from month to month round the whole of the British coasts will be accurately determined; and former investigations of the kind lead to the hope that considerable light may be thrown on the movements of various species of fish.

Another important step taken within the last quarter was the appointment of Mr. Hughes, a chemist from Professor Meldola's laboratory, to carry on experiments as to the production of artificial baits. Mr. Hughes arrived on the 24th of February, and has since been busily engaged in making extracts of all the animals most commonly used as bait. The methods of making and applying these extracts, together with the results of trials, will of course form the subject of subsequent papers. For the present it is enough to state merely the general lines upon which the work is proceeding.

Dr. Grenfell, superintendent of the Mission to Deep Sea Fishermen, who has previously furnished collections of pelagic animals taken by means of the surface net, has kindly consented to add the taking of temperatures to his other observations. With this object in view, the thermometers already in his possession have been carefully examined, and he has been furnished with an additional instrument. Specially prepared books have also been provided so that he may the more easily tabulate his results.

The tank room of the Laboratory, from being open to the public only one day in the week, is now open every day (Sunday excepted), a small charge being made for admission. The system is in every way proving a success; the attendance, especially on holidays, remaining all but up to the former standard. Members are of course still admitted at any time free of charge.

The storm of the 9th of March, so disastrous to shipping and property generally, caused considerable damage to the boats of the Association. One, the hook and line boat, was fortunately beached for repair and escaped injury. The steam-launch was sunk at her moorings and had her funnel, two water tanks, and all inside fittings carried away. The pulling or sailing boat and dingey were

both washed ashore, the former having her mast and inside woodwork considerably injured, but the latter, though found half full of mud and snow, has proved to be little the worse. The launch is now under repair and is to be handed over in a finished condition on the 9th of May.

The catalogue of books in the Library has been considerably augmented through the kindness of several members and others.

A valuable hydrometer has also been presented to the Association by D. Y. Buchanan, Esq., F.R.S.

With regard to the working of the Laboratory itself, little need be said, since all the important work of the staff is from time to time published in the Journal. In addition to the ordinary tanks, a hatching box on Captain Dunnevig's principle has been constructed and is now being used by Mr. Cunningham. The severity of the past season seems to have affected the animals in the tanks; the mortality, I am informed, has been decidedly above the average. Larval forms, also, seem scarce in the open sea, the tow-net showing enormous numbers of copepods, &c., but as yet (April 14th) not many larval stages of any importance.

Several experiments have been made with a view to determine the composition of the sea-water in this locality. The water outside Plymouth Sound, in the open Channel, has been compared with that just below the Laboratory, at the mouth of the pipe which supplies the tanks. The two samples agree in every way. The water in the tanks of the Laboratory has since been tested, with this somewhat singular result, that although perfectly normal as regards density it is distinctly deficient in carbonates.

This may possibly result from the system of keeping the same water in circulation over and over again without a fresh supply being brought in from the open sea; it should therefore easily be got over by more frequent pumping, the water at the mouth of the pipe being all that can be desired.

During the winter months only two gentlemen, other than the Permanent Staff, have taken advantage of the Laboratory :—E. A. Minchin, Esq., Anatomical Department, Oxford (Sponges), and T. H. Riches, Esq., late of Caius College, Cambridge (Paguridæ).

W. L. Calderwood.

The Plymouth Mackerel Fishery of 1889—90. From Data collected by Mr. Wm. Roach, Associate Member M. B. A.

By

W. L. Calderwood.

The returns kindly sent in by Mr. Roach have been tabulated in the following pages.

The period during which Mr. Roach made his observations extends from October 23rd, 1889, to September 29th, 1890.

Concerning the particular localities in which the fish have been caught, it may be useful, for those who are not familiar with the coast, to explain that the fish make their appearance on the coast at a considerable distance to the east of Plymouth (18—20 miles). The shoals then appear to travel in a westerly direction, some going off into deeper water, all moving about in a more or less uncertain manner. The head-quarters of the fishery eventually become fixed south of Plymouth and Eddystone Light. Gradually the fish seem to approach the shore, swimming now in large shoals. Many enter Plymouth Sound and are taken in comparatively shallow water, while others travel west, also in shallow water. The "remarks" for August are instructive. We find that, besides the ordinary and large fish, there are also "small fish about the size of pilchards" in the Sound, that "numerous large shoals" are noticed, and that at a later date the fish "seem to be leaving Plymouth Sound." On September 1st we find the note that "the mackerel are going off into open water and the shoals breaking up." On the breaking up of the shoals the mackerel fishing is considered to be at an end.

Concerning the forming of the shoals Mr. Roach also makes some remarks. I quote from his paper, "May 3rd: Mackerel are now gradually drawing to land. Some years ago they used to shoal in May, but of late years they have not shoaled so early. . . . I think it is owing to our April month being often so stormy. . . . Last year they did not shoal until July (1889)."

On June 21st he says, that, on an average, the shoal mackerel are much smaller than those taken with hook and line.

Such remarks as these serve to throw some light on the systematic movements of the mackerel shoals. Like the herring, they appear at certain parts of the coast at certain seasons, are driven by instinct to approach the land, and penetrate into the arms of the sea. At the same time shoals of younger fish are present, behaving in exactly the same way. The experience of fishermen goes to prove that the shoals of different sized fish do not intermingle; after a time the fish recede from the land and the shoals break up. But we also notice that there are certain causes which may retard or accelerate this series of movements. Meteorological conditions may affect the fish directly or they may affect their food, but since we have no regular record of the state of the weather, temperature of the sea in which the shoals swim, state of their food or reproductive organs, we are unable to discuss this point.

In relation to the state of the wind and the actual takes, however, this passing note may be made, that stormy weather seems to be favourable for "whiffing" (trolling a spinning bait), as the mackerel then seem to come to the surface, but whether the smaller classes of fish may not be taken at the same time by sunken nets is uncertain. As a rule only the largest fish are caught by "whiffing."

It is difficult to give, with any degree of accuracy, the total number of mackerel landed, since the record of the number of boats fishing is often incomplete. Such a record is, of course, not easily obtained except through some one regularly in attendance at the fish quays.

In studying the price column it is necessary to understand that in Plymouth, as in almost every other fishing centre, weights and measures are considerably distorted. In selling mackerel or herring by auction, as landed from the boats, 100 always means six score.

A few notes as to the methods of catching mackerel in this locality may be of interest.

In addition to the ordinary sunk or floating net—too well known to require description—what is locally known as "brimming" is much practised, especially by the Cornishmen.

Brimming is carried on during quiet nights. As the boat sails slowly along, a man in the bows, at short intervals, stamps loudly with his feet, lets the stock of the anchor fall suddenly on the rail, or makes some other noise, keeping at the same time a sharp look-out. The shoals of mackerel, startled by the sound, make one or two darts through the water, and cause quick flashes of phosphorescence. The suddenness of the flash distinguishes herring or mackerel from other less active fish. This is called the brim, and

Date.	Locality.	No. of boats.	Catch per boat.	Wind. Force.	Wind. Direction.	Weather.	Price per 100.	Remarks.
1889. Oct. 23	Between Bolt Head and Start Point	—	24,000 and under	—	—	—	14/0–17/0	—
24	16 miles off Bolt Head	—	10,000 ,,	—	E.	Fine	14/0	—
25	20 miles S.W. of Start Point	—	10,000 ,,	Fresh	E.	—	14/0–16/0	Good quality. Considerable damage done by dog-fish (*Acanthias*). In 10,000 mackerel, 2000 to 3000 will have pieces bitten out of them by dogs.
26	12 miles S. of Salcombe	—	6000 ,,	—	—	—	17/6	—
30	S.S.W. of Salcombe	—	3000 ,,	—	—	—	25/0 large fish; 9/0 small fish	Storm.
31	S. of Salcombe	—	3000 ,,	—	W.	Fine	20/0–24/0	Dog-fish again very numerous.
Nov. 1	12 miles W.S.W. of Start Point	—	900 ,,	Gale	W.	—	17/0–21/0	—
2	—	—	—	—	—	—	—	Too stormy.
4	10 miles S. of Salcombe	—	400 ,,	—	—	—	21/0–25/0	—
5	6–10 miles S.W. of Start Point	—	2000 ,,	—	—	—	20/0–26/6	—
6	10 miles S.W. of Bolt Head	—	A few hundred	—	—	—	24/0	Fish scarce. Bright moon given as reason.
7	15 miles S.W. of Start Point	2 or 3	200	—	—	—	25/0	—
8	20 miles S. of Salcombe	3	200	—	—	—	25/0	—
9	—	—	—	—	—	—	—	Mackerel become so scarce boats starting pilchard fishing.
15	4 miles S.E. of Eddystone	3	200–300	—	—	—	37/0	The nets worked by these boats are half mackerel and half pilchard.
16	6 miles S. of Eddystone	4	200–1000	—	—	—	30/0	P. Z. boats.
17	15 miles S.S.W. of Start Point	4	400–500	—	—	—	30/0	P. Z. boats. Dog-fish are reappearing.
18	15 miles S.S.W. of Eddystone	—	200 and under	—	—	—	30/0	—
19	15 miles S.S.W. of Start Point	—	3000 ,,	—	—	—	34/0	P. Z. boats using sunken nets. Thousands of small mackerel are along the coast.
20	Ditto	6	1500 ,,	—	—	—	27/0	—
21	20–30 miles S.S.W. of Start Point	8	2500	Strong	E.	—	25/0–27/0	—
22	15 miles S.W. of Start Point	—	800 and under	—	—	—	27/0	—
23	20 miles S.S.W. of Start Point	3	400 ,,	—	—	—	26/0	Stormy.
27	15 miles S.S.W. of Start Point	5	300 ,,	—	—	—	37/0	Stormy.
28	15–20 miles S.W. of Start Point	6	1500 ,,	—	—	—	36/0	About 60 boats out.
29	20 miles S.W. of Start Point	—	400 ,,	—	—	—	26/6	A great many boats given up for want of luck.
		2	300					

Dec. 10	—	5	None	—	—	—	—	Got their nets full of dog-fish, greatly injuring the nets.
13	15 miles S.W. of Bolt Head	1	3700	—	—	—	37/0	—
		1	700					
17	15 miles S. of Plymouth	—	900 and under	—	—	—	37/0–40/0	Very large.
1890. Jan. 14	40 miles S. of Plymouth	1	1150	—	—	—	87/0	The first take of mackerel for nearly a month.
16	30 miles S. of Mewstone	1	700	—	—	—	84/0	—
		1 or 2	100					
Feb. 12	35–45 miles S. of Plymouth	1	2000–3000	—	—	Stormy	35/0–40/0	The presence of dog-fish complained of, injuring the mackerel.
		20	3000 & under					
15	28 miles S.S.W. of Start Point	—	450 and under	—	E.S.E.	,,	47/0	A gale followed, blowing from N.N.W.
17	—	—	200 ,,	—	S.S.E.	,,	100/0	—
18	—	10	30 ,,	—	E. by S.	,,	1/0 each	—
20	20 miles S. of Bolt Head	1	450	—	—	—	50/0	A calm followed.
22	—	2	700–1000	—	—	—	41/0	Caught by "brimming," encircling fish seen at night by the phosphorescence they cause when frightened.
		75	A few fish					
24	30 miles S.S.W. of Start Point	1	1900	Strong	E.	—	44/0	Sunken nets.
		1	1500					
		70	50 and under					
26	30 miles S.S.W. of Berry Head	Several	A few hundred	—	—	—	39/0–44/0	—
		1	4400					
		1	3000					
		1	1000					
Mar. 3	—	—	—	—	—	—	—	20 Lowestoft boats arrived without any fish after trying for 3 or 4 days.
5	—	Many	Very few					
	30 miles S.S.W. of Start Point	1	250	—	—	—	50/0	—
7	40 miles S. of Plymouth	1	300	Strong	S.W.	—	60/0	—
		8	20–30					
10	35 miles S.S.W. of Mewstone	6	350 and under	—	W.	Fine	75/0	Floating nets.
12	—	1	1500	—	W.	—	40/0–48/0	Largest catches taken in sunken nets.
		2	700					
		8	200–1000					
		1	400					
13	25–30 miles S.S.E. of Mewstone	30	1500 and under	—	S.S.W.	Very fine	37/0–41/0	Equally distributed between floating and sunken nets.

Date.	Locality.	No. of boats.	Catch per boat.	Wind. Force.	Wind. Direction.	Weather.	Price per 100.	Remarks.
Mar.								
14	30 miles S. of Mewstone	40	1300 and under	—	S.	Very fine	34/0–40/0	Sunken nets.
15	Ditto	20	100–300	—	—	—	38/0–41/0	A storm from S. followed.
		40	None					
19	Ditto	30	20–40					
	Ditto	5	500–600	—	—	—	53/0	Floating nets.
	40 miles S. of Mewstone	3	1000–1500					
20	40 miles S. of Plymouth	5	200–500	Fresh	N.W.	—	39/0–44/0	Floating nets. Several boats put back.
		4	1000–2000					
22	35 miles S.S.W. of Plymouth	20	1700 and under	—	—	—	31/0–33/0	Sunken nets.
24	Ditto	50	500 ,,	—	—	—	32/0–36/0	Storm from S.S.E. followed.
26	32–37 miles S. of Stoke Point	20	800 ,,	—	S.W.	Fine	44/0–50/0	Most of the boats not out. No boat with more than 800.
27	30–35 miles S. of Mewstone	30	20–1000	—	S.	Foggy	40/0	Floating nets by Lowestoft boats. Very few boats with fish, and few boats with more than a score of fish.
29	—	Several	Very few	—	—	—	—	—
31	30–35 miles S. by W. of Plymouth Harbour	1	2900	1	E.	Fine	48/0–50/0	The fish are being caught further and further west. The large takes were got by floating nets, the small by sunk nets.
		1	1000					
		15	100–400					
April								
1	30–40 miles S.W. of Eddystone	30	900 and under	—	—	—	40/0–50/0	In floating nets.
2	30 miles S.W. by W. of Eddystone	20	800 ,,	3	E.	—	35/0–40/0	Floating nets. Taken in the early morning after the moon went down. Fish still travelling west. Each boat getting 10 or 12 garpike with the mackerel. Large quantities of small Crustacea noted on surface of water.
5	—	—	—	—	N.E. a.m. S.E. noon	—	—	Poor takes. Attributed to the very bright moon.
7	—	4	400–500	—	—	—	—	Only 3 or 4 boats with fish.
10	20–30 miles S.S.W. of Start Point	50						
	30–40 miles S. of Plymouth Harbour	} 6	800 and under	3	N.	—	25/0–35/0	Many boats with no fish. Fish of poor quality.
	20–30 miles S.S.W. of Eddystone	} 44	25–100					
	30 miles S. of Deadman Point							
11	40 miles S. of Plymouth	4	400 and under	—	—	—	27/0	Floating nets. Fish of poor quality.

12	20–30 miles S.W. of Eddystone	2 7	700–800 300–400	—	E. a.m. S. noon, backing.	—	27/0–30/0	Boats taking to the floating nets.
14	40–50 miles S.S.W. of Eddystone	4	1000 and under	4	E.	—	27/0–30/0	—
15	—	4	200	4	E., abating	—	—	Too stormy for much fishing.
16	50 miles S.S.W. of Eddystone	4	2000–3000	Strong	E.	—	27/0–34/0	—
17	—	—	—	,,	E. by N.	—	—	A few boats with few fish.
18	—	—	—	—	—	—	—	Too stormy for fishing.
19	45–50 miles S. by W. of Eddystone	3 Others	2900 & under 1200 ,,	Light	E. by N.	Fine	19/0–21/0	—
21	Ditto	4	2000 ,,	Fresh	S.	Foggy	19/0–20/0	—
23	Ditto	2 3	5000 2000 & under	,,	S.W.	—	30/0–34/0	—
24	35 miles S. by W. of Eddystone	8	500 ,,	—	N.W.	—	30/0–32/0	Large quantity of small Crustacea noticed on surface.
28	—	—	—	—	W. by S.	Fine	28/0–30/0	Only a few hundred fish taken.
29	25 miles S.W. of Eddystone	8	500 and under	Fresh	S.E.	—	27/0	—
30	20 miles S.E. of Plymouth	20	100–300	—	E. by S.	—	31/0	—
May 1	20–30 miles S.W. of Eddystone	8	1000–2000	—	E.	Fine	30/0	—
2	10–15 miles S.S.W. of Eddystone	10	100–300	Calm	E.	—	27/0–29/0	Too calm to enable boats to go far to sea.
3	10–15 miles S. of Eddystone	15	800 and under	—	—	—	17/0–18/0	Quality rather poor. The fish are now being taken nearer the land. Mackerel said to be shoaling later.
5	5–8 miles S. of Eddystone	15	700 ,,	—	S.E.	—	30/0	—
6	Outside Eddystone	—	1000–1500	—	S.E.	Showery	17/0–18/0	—
8	10–20 miles S. of Eddystone	Several	100–300	—	E. by S.	—	17/0–20/0	Quality rather poor. Several Lowestoft boats visited Plymouth, but also doing very badly, although having tried off Falmouth and St. Ives.
10	—	,,	Poor takes	—	S.E.	Fine	—	—
12	—	,,	100–300	—	S.W.	,,	—	—
13	30 miles W.S.W. of Eddystone	1 1	3000 1000	—	N.	,,	16/0–20/0	—
14, 15	—	—	A very few fish taken	Fresh	S.W.	,,	—	—
17	50 miles W.S.W. of Eddystone	1	5000	—	S.W.	—	16/0	Many boats out, but only about 1 in 20 with a few fish.
19	—	—	Poor takes	—	S.W.	Fine	—	No boat with more than 100 fish.
20	3–4 miles S. of Eddystone	—	,,	—	—	—	$2\frac{1}{2}d.$ each (for bait)	—

Date.	Locality.	No. of boats.	Catch per boat.	Wind. Force.	Wind. Direction.	Weather.	Price per 100.	Remarks.
May 22	S. of Eddystone	—	A few hundred	—	S.E.	Fine	Sold for bait	—
23	8–10 miles S. of Eddystone	8	1800 and under	—	E.	"	11/0–13/0	Also 200–300 herrings per boat. Mackerel very small. These were L. T. boats, using a smaller mesh at this season.
26	Between Penlee Point and Rame Head	—	5000	—	E.	"	12/0–14/0	Also some boats got from 4–6 doz. by hook.
27	Ditto	—	4–6 doz.	—	E.	—	—	By hook.
28	Off Penlee Point	2	3000	—	E.	Fine	12/0	Seine net.
29	Ditto	—	A few hundred	Fresh	W.	—	12/0	Drift nets.
	Close off Penlee Point	1	3000	—	—	—	—	Seine net.
June 2	—	—	2000–3000	—	N.W.a.m.	—	—	Port Rinkle boats.
	—	—	3000	—	W. p.m.	—	—	Cawsand boats.
	40 miles S. of Penzance	2	2000–3000	—	—	—	13/0–14/0	Lowestoft boats. Large fish.
3	—	—	2000–3000	Fresh	S. by W.	—	14/6	Plymouth boats.
			2000–3000	—	—	—	14/6	Cawsand boats.
4	½ mile off Penlee Point	—	3000	—	S.W.	—	12/6	Cawsand boats.
5	—	—	2000	—	S.W.	—	12/6	Cawsand boats. Each boat had also a few dozen trolled mackerel.
			6000	—	—	—	—	Port Rinkle boats. Caught by trolling.
6	—	2	1000–2000	Strong	S.W.	—	14/0	Each boat had also a few dozen trolled mackerel.
	30–40 miles off Scilly	5 or 6	2000–3000	—	—	—	16/0	Very large fish.
7	Off Scilly	—	A few thousand	—	S.W.	Fine	12/0	P. H. boats having very poor success.
9	Off mouth of Plymouth Sound	—	10–15 doz.	—	W.	—	1/4–1/6 per doz.	All taken by trolling, locally termed "whiffing."
	Off Cawsand	2	2000	—	—	—	14/6	Seine nets.
10	½ mile S. of Penlee	—	20–30 doz.	—	—	—	—	By the hook and line boats (whiffing?). Great complaint about the gun practice here.
11	Ditto	—	10–20 doz.	—	W.S.W.	—	1/2–1/4 per doz.	By hooks (whiffing?).
12	Ditto	—	10–40 doz.	—	N.W.	—	1/3–1/6 per doz.	By hooks (whiffing?). A few also caught in the drift nets.
13	1–2 miles S. of Mewstone	—	10–15 doz.	—	E.	—	1/0–1/5 per doz.	Gun practice requiring the boats to go farther to sea than they would otherwise have done.
14	Off St. Ives	10	500–1000	—	W.	Fine	12/0	Taken in drift nets. Sold at Plymouth. Boats bound home to Lowestoft. They have made £100 to £380 in 6 to 8 weeks.

16	Ditto	8	500–600	—	S.W.	"	13/0	These boats also bound home to Lowestoft. Two of them are said to have made £380; the rest about £200 each.
17	Between Rame Head and the Eddystone	—	200–900	—	S.W.	"	15/0–16/0	—
18	S. of Eddystone	—	600–700	—	W.S.W.	"	15/0	Taken by hook.
19	6–10 miles S. of Eddystone	—	400–700	—	W.	"	13/0–15/0	By drift nets.
20	5–10 miles S. of Eddystone	—	100–200	—	—	—	13/0–15/0	Drift nets.
			200–300	—	—	—	—	Whiffing.
21	—	—	200–600	—	S.W.	Fine	14/0	Whiffing.
			200–300	—	—	—	—	Drift nets. Gun practice said to break up the shoals.
23	20–30 miles S. of Plymouth	—	400–500	—	W.	Fine	14/0	Whiffing 2–3 fathoms below surface.
		20–30	1000–1800	—	—	—	15/0	Whiffing. These boats went out on 22nd.
25	—	—	400–500	—	S.W.	Fine	16/0	Whiffing.
26	—	40	400–500	—	W.N.W.	"	16/0	A number of boats after whiffing to sunset shot drift nets, but only took about 50 fish per boat.
27	—	—	200–500	—	—	—	17/0	Whiffing.
28	25–30 miles S. of Mewstone	—	300–400	—	—	—	16/0	The whiffing boats have made from £10 to £18 in the past week.
	Between Penlee Point and Rame Head	—	2000	—	—	—	12/0	Seine net. Almost all boats have given up trying to catch mackerel by drift nets.
30	—	2	4000	—	N.W.	—	14/0	Seine net.
July								
1	Port Rinkle	4	1000–2000	—	S.W.	—	15/0–16/0	—
3	Ditto	6	1000–2000	—	—	—	16/0	Seine net.
	20 miles S. of Eddystone	—	400–1000	—	N.W.	Fine	16/0	Whiffing.
4	—	—	400–500	—	—	—	14/0	Whiffing.
5	—	—	500–1000	—	—	—	13/6	Whiffing.
7	—	2	1000–2000	Strong	S.W.	Rain	14/0	Seine nets.
			100–300	—	—	—	—	Drift nets.
8	—	20	100–600	—	—	—	16/0–18/0	Whiffing. Wind increased to a gale, which seemed to favour the whiffing, the mackerel coming to the surface in great numbers.
10	—	—	—	—	S.W.	Fine	—	No mackerel to be found by any boat. Messages sent over from Guernsey asking boats to come over, fishing being good there.
16	Between Penlee Point and Eddystone	—	2 or 3 doz.	—	—	—	—	Still no mackerel on usual ground.
17	Ditto	—	10–15 doz.	—	Variable	Showery	2/0 per doz.	Fresh shoals of mackerel arrived. Whiffing.
		1	2000	—	—	—	21/0	Seine net.
		1	1000	—	—	—	—	Seine net.

Date.	Locality.	No. of boats.	Catch per boat.	Wind. Force.	Wind. Direction.	Weather.	Price per 100.	Remarks.
July 21	1 mile S. of Mewstone, Penlee Point, and Rame Head	—	100–300	—	N.W.	Dull a.m. Fine p.m.	17/0–18/0	Whiffing.
22	—	—	100–200	Fresh	N.W.	—	16/0	Whiffing.
		1	1000					
		1	1500					
23	—	—	100–200	—	N.W.	Fine	—	Whiffing.
		1	1500					
24	—	2	800	Fresh	W.	—	12/0	Seine nets. The whiffing has rather fallen off.
25	—	2	500–600	Light	S.	—	11/6	Seine nets.
	Mouth of Plymouth Sound	30	100–300	—	—	—	12/6	Whiffing.
26	Cawsand	1	1000	—	S.W.	—	—	Seine net.
29	—	—	100–300	—	S.W.	Fine	12/0	Whiffing.
30	—	—	100–150	—	—	—	—	Whiffing.
		1	1000	—	—	—	11/6	—
31	Between Knap Buoy and Penlee Point	—	100–200	Fresh	S.W.	—	11/0	Whiffing.
Aug. 1	—	—	5–10 doz.	—	S.W.	Foggy	11/6	—
2	—	—	A few hundred	—	N.	”	—	6 large shoals of mackerel seen off the Sound, but not taken in any quantity (a few hundred by whiffing).
4	Cawsand Bay and Whitsand Bay	6	1000–1500	—	N.W.	Fine	10/0–11/0	Seine nets.
5	—	—	3000	0	—	”	11/0	—
6	—	5	1000–2000	—	—	—	14/0–14/6	Seine net.
7	—	3	3000	—	—	—	13/0–14/0	Seine net.
9	Between Mewstone and Rame Head	—	100–300	—	—	—	15/0	Whiffing.
			4000	—	E.	Fine	14/6	Seine net.
11	—	—	100–200	Fresh	W.	—	15/0	Whiffing. Many small mackerel on the coast at present. When caught sold at 4/0 per 100.
12	—	—	100–150	—	—	—	14/6	—
19	Plymouth Sound, inside	—	3–4 doz.	—	Variable	—	2/0–2/6 per doz.	—
22	—	—	100–200	—	—	—	12/0–14/0	Large fish.
			100–200	—	W.	Fine	2/0–4/0	Small fish; about the size of pilchards.
23	Between Penlee Point and Rame Head	—	100–200	—	—	—	—	Numerous large shoals noticed, but poor fishing. Seem to be leaving Plymouth Sound.

25	—	—	100–300	—	—	—	14/0 and 3/0	Large and small. Whiffing.
26	—	—	100–300	—	—	—	14/0 and 3/0	—
30	—	—	50–100	—	—	—	25/0	Large.
			100–200	—	—	—	7/0	Small.
Sept. 1	5–10 miles S. of Eddystone	2	200–400	—	—	—	35/0	Drift nets. These boats are now fitting out, the mackerel going off into open water. Shoals breaking up.
2	Ditto	4	500–1000	—	—	—	—	Drift nets.
3	—	—	300–1500	—	N.W., backing	—	—	—
4	—	—	500–800	—	N.W. and	—	25/0–35/0	—
	Centre of Sound	—	1–2 doz.		S.W.		—	Whiffing. Large fish.
5	—	—	500–3000	—	—	—	10/0–15/0	Drift nets. Also large quantities of small mackerel by hook and net.
6	—	—	100–2000	—	Very variable	—	6/0–7/0	Market too full of all kinds of fish for prices to be good. Pilchards as low as 1/6 per 1000.
8	5–10 miles S. of Eddystone	—	500–5000	—	E.	Fine	—	Still enormous quantities of pilchards and thousands of common shad.
11	—	60	500–1500	—	—	—	10/0–12/6	—
13	—	—	500–600	—	—	—	10/0–12/6	—
15	—	—	100–500	—	—	—	14/0–16/0	—
18	—	—	Poor takes	—	S.E.	—	0/9–2/6 per doz.	—
23	—	10	400	—	S.W.	—	15/0–17/0	—
24	—	2	2500					
	—	5	600					
	—	40–50	25–2000	—	—	—	17/0	—
25	—	—	100–600	—	—	—	17/6	—
26	10–15 miles S. of Eddystone	40	2000 and under	—	—	—	15/0–17/0	Majority of catches 300–600.
	8–10 miles off Foyee and Lowe	40	2000–4000	—	—	—	17/0	—
27	—	3	2000	—	S.W.	Fine	11/0–13/0	—
	—	6	800–900					
	—	20	100–200					
29	—	4	300 and under	—	—	—	—	—

by it the size of the shoal is estimated, as well as the depth at which the fish are swimming. The net is regulated accordingly, and the shoal encircled.

The famous Lochfyne herring are also for the most part caught by this process.

Whiffing or trolling for mackerel with a spinning bait has also been practised for many years. Each boat works six lines. Each line is attached to a sinker, from which depend first a fathom of snood, then a fathom or a fathom and a half of gimp, a swivel, a foot or so of gut, and the swivel bait or spinner. When fish are plentiful, the bare spinner will take fish well. At other times it is necessary to have a fish bait.

The bait most preferred is called "britt" or "mackerel bait" (young sprat, whitebait). When this cannot be procured a substitute is manufactured by cutting about an inch out of the under or white surface of a mackerel's tail.

One remarkable circumstance of last season's "whiffing" was that boats engaged in this method of fishing south of the Eddystone had to be sailed in a southerly direction. In June boats sailing for ten to fifteen miles south of the Eddystone would pick up from 200—400 in one course. They then got "outside" of the fish, and had to return to their starting-point to repeat the process. While sailing back, although the lines were kept out all the while, only a very few fish could be taken.

This method of fishing can only be employed during daylight.

The Lobster Fishing of one Boat in Plymouth District, from May 1st to September 29th, 1890.

The data for this paper were again supplied by Mr. Roach, and have all been reduced to tabular form. I shall here state only the general results.

The total number of lobsters taken was 1753. Of these 1226 were males and 527 females, *i. e.* 699 more males than females.

Concerning the number of "berried hens" in each month, we find—

In May, 21 out of 105 females.

In June, 21 out of 133 females.

In July, till 11th day of the month, 14 out of 47 females.

On July 11th notes as to presence of females with ova end abruptly, nor is any note made of the number in August. On September 8th there is note of one female, on the 15th two, on the 22nd one, on the 26th three, 27th two, and 29th two.

The notices of soft-shelled lobsters are also confined to the first part of the paper. In May about three out of every four males are soft, most of them measuring eight to ten inches. There are eighteen females mentioned as having soft shells.

It is to be regretted that the last two items have not been attended to more carefully.—W. L. C.

On the Reproduction and Development of the Conger.

By

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I. *Review of previous Observations on Sexually Mature Conger.*

Before the Laboratory of the Association was built, it had often been observed in other aquaria that female conger after living for some time in captivity, feeding regularly and voraciously, and growing with considerable rapidity, passed into a swollen and apparently gravid condition and then died. Such conger when dissected after death were invariably found to contain enormously developed ovaries or roes, which entirely filled up and distended the abdominal cavity, and pressed the intestine and other abdominal organs into as small a space as possible. The following are the principal records of cases in which this has been observed.

R. Schmidtlein* gives an account of the occurrence in the aquarium of the Zoological Station of Naples in a paper published in 1879. He writes, "All that we can say concerning the reproduction of the conger, is that sometimes the body of large specimens became considerably swollen as though distended with gas, and these specimens hung for some days at the surface of the water on their sides, without eating and without the power of swimming, and then died. When opened, the abdominal cavity was found filled, almost to bursting, with colossal masses of eggs, and all the organs were compressed and reduced to a minimum. In some of these specimens some small masses of eggs were extruded even during life, but the deposition of large numbers of eggs never occurred. All died from the presence of the excessive numbers of eggs which from causes difficult to understand could not be expelled from the body." In a table† published the same year, the same author states that

* *Beobachtungen über die Lebensweise einiger Seethiere innerhalb der Aquarien der Zoologischen Station*, Mittheil. aus der Zoolog. Station zu Neapel., Band i, 1879, p. 492.

† *Beobachtungen über Trächtigkeits- und Eiablage-perioden verschiedener Seethiere*, Mitt. Zoolog. Stat. Neapel., Band i, 1879, p. 135.

two specimens in this condition died in the middle of August, and he adds that large numbers of young conger scarcely 3 cm. ($1\frac{1}{4}$ inches) long are captured in the middle of April. Schmidtlein does not give the measurements of the gravid conger which he mentions, but he calls them large, and in another place says that the fish grows to a length of over 2 metres (6 feet), so that it is probable the gravid conger were 5 or 6 feet in length.

Similar observations upon female conger are recorded by Dr. Otto Hermes, the Director of the Berlin Aquarium, in the *Zoologischer Anzeiger*, vol. iv, 1881. Dr. Hermes states that he is convinced that the development of the ovaries of the conger in captivity is often a cause of death. When some females which had died in the Berlin Aquarium were opened, the ovaries were found to be much enlarged, and one which died in the Frankfort Aquarium was actually burst by the extraordinary development of the ovaries. This specimen weighed $22\frac{1}{2}$ lbs., the ovaries weighed 8 lbs., and the number of eggs in them was calculated to be 3,300,000.

According to Francis Day (*Fishes of Great Britain and Ireland*) a female conger which died in the Southport Aquarium in June, 1876, weighed $15\frac{1}{4}$ lbs., and the ovaries 7 lbs., the number of eggs in which was calculated at 6,336,512. It is evident that these calculations are probably not very accurate, for according to the latter there would be nearly a million of eggs to 1 lb. of ovary, while according to that of Hermes, there would be only about one million to 6 lbs. of ovary.

These are the only published observations concerning the ripe ovary of the conger that I have been able to find. With regard to the structure of the ovaries the most complete account is that given by Brock* in 1881, and founded on observations made at Naples. I have in a previous number of this Journal briefly described the external structure and relations of the ovaries. There is one ovary on each side of the mesentery suspending the intestine. Each consists of a long ribbon-like membrane, attached dorsally, with a free edge ventrally. The median side of the ribbon is smooth and flat, the lateral side bears a series of very numerous thin plates or lamellæ, attached to the ribbon-like membrane edgewise and transversely, and in contact with one another by their faces like the leaves of a book. These lamellæ contain the numerous small ova. Thus the ovary is not a closed tube as in most fishes, and consequently the eggs when they leave the ovary lie free in the body-cavity, whence they escape by an aperture behind the anus.

We have next to ascertain what was known up to the commence-

* *Untersuchungen über die Geschlechtsorgane einiger Muraenoiden*, Mitt. Zool. Stat. Neapel., Band ii, p. 415.

ment of my own observations concerning the male conger. The most convenient publication to start from in this inquiry is Hermes' paper already mentioned. The principal subject of this paper was the discovery of ripe testes full of ripe actively motile spermatozoa in a specimen of the conger. The specimen was one of a number caught near Havre, and sent to the Berlin Aquarium in the autumn of 1879. These specimens when they arrived were 60 to 70 cm. long (2 feet to 2 feet 4 inches). They all throve in the aquarium and grew rapidly with the exception of one, which increased very little in size, and which died on June 20th, 1880. It was then 74 cm. ($29\frac{1}{10}$ inches) in length. When this specimen was opened organs were seen in it which looked like ripe testes, and when a cut was made in one of these milt flowed from the incision; this milt was found on examination under the microscope to be swarming with actively moving spermatozoa.

The form and size of the ripe testes are carefully described by Hermes. Each was an elongated laterally compressed mass fastened at the side of the air-bladder by a suspending membrane. The greatest breadth of the organ was 18 mm. ($\frac{7}{10}$ths inch), its greatest thickness from side to side 9 mm. (·36 inch). Each organ extended through nearly the whole length of the body-cavity, commencing near its anterior end and continuing some distance behind the anus. A number of transverse fissures divided each organ into several lobes, namely five in the right organ, and about the same number in the left. At the base of each organ was a closed duct or vas deferens through which the milt was conveyed to the exterior. Opposite the rectum a downward branch passed from each vas deferens, and these two branches united to open by a single aperture behind the anus to the exterior. Hermes points out that the testes of the conger discovered by him, correspond, when allowance is made for the fact that they were ripe and fully developed, very perfectly with the lobed organs of the common eel described by Syrski in 1874. He concludes, therefore, that Syrski's organ is, as that author believed, the testis of the male eel. The conger further agrees with the common eel in the relation of the size of the male to that of the female, Syrski having found that the male eel was considerably smaller than the female.

Dr. Syrski,* while holding the post of Director of the Museum of Natural Sciences of Triest , was commissioned by the authorities of that town to ascertain the spawning season of the fishes of the neighbourhood. He included the eel in his researches, and con-

* My knowledge of the investigations of Syrski and Jacoby is derived from a translation of Jacoby's work on *The Eel Question*, in the Report of the U.S. Commissioner of Fisheries for 1879. Washington, 1882

sidering that in many animals the male is smaller than the female, he began to look for male eels among the smaller specimens. In the second specimen he examined, which was 40 cm. (16 inches) in length, he discovered the organs which he identified as testes. His conclusion as to their nature has been confirmed by all subsequent inquirers, although no one has yet found these organs in the ripe condition, and thus brought the final evidence of demonstrating the ripe spermatozoa of the eel.

The largest male eel observed by Syrski was 43 cm. (17 inches) in length. But Dr. L. Jacoby, who investigated the eel both at Trieste and Comacchio after Syrski, in 1877, found males as long as 48 cm. ($18\frac{9}{10}$ inches) and as small as 24 cm. ($9\frac{4}{10}$ inches) in length. The female eels reach a length, according to Jacoby, of one metre (39 inches) and the thickness of a man's arm, but the majority of adult females which migrate in autumn to the sea are not longer than 70 cm. ($27\frac{1}{2}$ inches). Therefore if Hermes' specimen of the male conger is of the average size of the male in that species, then there is a much greater difference in size between the sexes in the conger than in the eel. The male conger discovered by Hermes was 2 feet $5\frac{3}{5}$ inches long, while adult females are 5 to 7 or even 8 feet in length. The largest male eel recorded by Jacoby was 1 foot $7\frac{1}{5}$ inches long, while adult females are only 2 feet 4 inches to 3 feet 3 inches long.

Brock, in his account of the researches he made at Naples, does not include any discussion of the relative sizes of the two sexes. Of the conger he merely says that he examined forty-five specimens, of which the males and females were about equal in number. He states that he obtained only one male which was perfectly ripe, and that he got this in the middle of November. The size of this specimen he neglects to mention. Of the female sex Brock describes no ovaries far advanced in development, and here also he neglects to mention the size of the specimens which he examined. Of the common eel Brock only states that out of ninety specimens of 35 cm. (14 inches) in length and under which he examined, seventy-nine or 88 per cent., were males, and among those of 35 to 40 cm. (14 to 16 inches) in length six were males.

II. *History of my own Observations.*

I have now to record the observations and experiments on the conger which I have made at the Plymouth Laboratory from November 7th, 1887, up to the end of the year 1890. I find that my notes on the conger in No. 2 old series of this Journal, although

dated February 29th, 1888, only comprise my observations up to November 7th, 1887, at which time I had not met with a male specimen.

On November 17th I bought eighteen small specimens on the fish-quay. The smallest of these was 1 foot 4 inches, the largest 2 feet 8 inches long. One of them, 1 foot 8 inches in length, was a male with well-developed but not ripe testes. The testis was 7 mm. broad and 2 mm. thick (about $\frac{1}{4}$ inch broad, $\frac{1}{12}$ inch thick). In form and relations this testis agreed with the description given by Hermes, except that there was no division into lobes; the organ was continuous from end to end. Two other specimens were very young males, 18 and $19\frac{1}{2}$ inches long respectively; ten were females, and in five of the smallest the reproductive organ was so undeveloped that the sex could not be determined.

On December 4th I examined the ovary of a very large conger over 6 feet in length; the ovary was large, forming a milk-white opaque elongated mass on each side of the body-cavity. The organ was 8 cm. wide, the ova or eggs visible as separate grains to the unaided eye. Measured under the microscope the eggs were found to be ·5 mm. in diameter; they were perfectly opaque and granular, and spherical in shape. The ovary contained, besides very numerous ova, a good deal of fat-tissue.

On March 2nd, 1888, I got the roe of a large conger, 5 or 6 feet long, from the fish-quay. The ova in the roe were visible to the unaided eye, and when measured were found to have a diameter of ·5 to ·7 mm.

In ovaries less developed than these the ova are not separately visible to the unaided eye, and can only be seen when a piece of a lamella is examined with the microscope. The appearance then

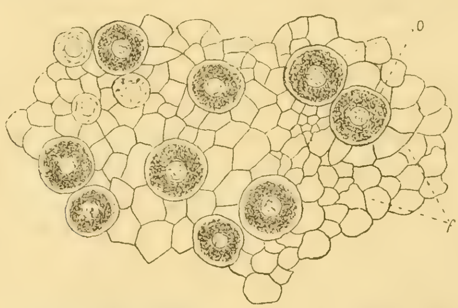


Fig. 1.—Portion of lamella from immature ovary of conger under low power of the microscope. *o.* Ova. *f.* Fat-cells.

presented by the fresh tissue is that shown in the woodcut, fig. 1; the small ova are still transparent enough to show the germinal

vesicle in the centre, and they are irregularly distributed throughout the fat-tissue which makes up the greater part of the bulk of the ovary. The conger from which the figure was taken was 5 feet 3 inches long, 24½ lbs. in weight, and captured and killed on October 6th. Fig. 2 shows a portion of a lamella of the ovary of an eel 22 inches long killed December 10th; the ova here were ·14 mm. in diameter. Fig. 2 is from a more highly magnified image than fig. 1, and the ova are also somewhat more developed.

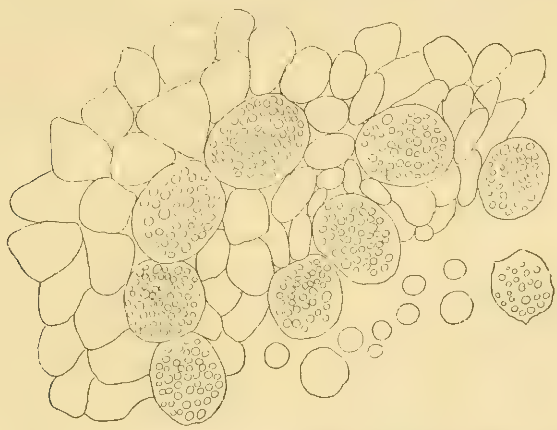


FIG. 2.—Portion of lamella from immature ovary of common eel.

The aquarium of the Plymouth Laboratory was filled with sea-water and ready for use by June 30th, 1888. Before this time, as appears from the above observations, I had not succeeded in procuring ripe conger, either males or females, from the fishermen, and I hoped to obtain more light on the subject of the reproduction of the species by keeping specimens in captivity.

Very soon after the aquarium was in working order several living conger, some large some small, were placed in it, and they throve well, feeding voraciously on squid (*Loligo*) and pilchard, and some of them growing considerably.

The first interesting result I obtained from the aquarium was the discovery of a perfectly ripe male on December 13th. My notice was attracted to this specimen in a tank by its peculiar appearance. It was quite a small specimen and somewhat thin; the peculiarities about it were its large prominent eyes and short broad snout. The eyes were so large in proportion to the head that their upper edges projectly slightly above the dorsal surface of the skull, and that surface between the eyes was quite depressed and hollow. Before seeing this specimen I had not noticed any

differences by which male congers could be distinguished from females of the same size, although I had found that all the large specimens (3 feet long and upwards) were females. I took out this specimen, intending to kill it and examine its generative organs, but before killing it I held it alive in a cloth and gently squeezed its abdomen towards the generative aperture. Thick fluid white milt immediately exuded from the aperture, and when I examined a little of this milt under the microscope, I found it swarming with innumerable ripe spermatozoa in most active motion. As the specimen was not in the least injured by the squeezing, I placed it in a tank by itself and kept it alive for further observation. It was 45 cm. (18 inches) long.

Two days afterwards I found a small conger dead in another tank. This also proved to be a ripe male; its length was 51 cm. (20 inches). From the front of the eye to the end of the snout measured 19 mm., the breadth between the eyes 17 mm. The testis was 14 mm. wide ($\frac{5}{8}$ inch) and in colour milk-white.

On December 19th eight conger were caught for me near the mouth of Plymouth Sound, with hook and line. They seemed to me to be too large for males, and I concluded they were young females. However I kept them alive; there was one, the smallest, about which I was doubtful, thinking it might be a male. The next day I squeezed this specimen, but could get no milt from it. At this time I was not experienced in detecting the peculiarities of the male in unripe specimens. This specimen when killed and opened proved to be a male with large well-developed almost ripe testes. The specimen was $19\frac{1}{2}$ inches long (48 cm.). A piece of the testis examined under the microscope showed no ripe spermatozoa.

I then opened another of the specimens caught on the 19th. I was confident that this one was female, but it proved to be a male with fully-developed but not ripe testes. A few ripe spermatozoa were found on teasing up a portion of the testis. This was the largest male I had yet seen, it was 2 feet 2 inches in length (66 cm.). The testis on the left side was 3 cm. wide (from attachment to edge). I pressed ripe milt with my finger, after the abdominal cavity was laid open, into the vas deferens at the base of the testis, and thence along the transverse duct behind the rectum to the exterior.

These two males were not darker on the back and sides than a female 2 feet 3 inches long, with which I compared them; in fact both of them were piebald, some parts of the skin being quite light, others dark. But there was a difference in the colour of the ventral surface, which in the female was pure white, entirely without pigment, and in the male was clouded to a considerable degree with black pigment cells. The prominence of the eyes previously described in

a ripe male was not visible in these last two, which were almost ripe. But I detected another constant difference which enables one to detect a male with almost absolute certainty, whether they be ripe or unripe. In the female the outline of the head when looked at from above is triangular, the snout being pointed; in the male the same outline is much less pointed, the snout being distinctly blunter. Also in the female the dorsal surface of the snout in front of the eyes is arched, so that a transverse section of the dorsal surface is an arc of a circle; in the male the surfaces of the snout are flat, its sides above the mouth being perpendicular, and the upper surface almost level, so that a transverse section forms three sides of a square.

However, I found I still required some practice before I could distinguish males among a number of live conger with certainty. On December 21st I examined three small specimens, and concluded that two were female, while the third was doubtful. I killed the latter, and it proved to be a male 58 cm. (23 inches) long, with very small and undeveloped testes.

Of course the identification of the males is more difficult the smaller and younger the specimens under examination. On January 1st, 1889, I received four small living conger, which were pale reddish and delicate looking. I decided that two of these were females, and therefore killed them, keeping the other two alive among the males I was collecting. But the two I killed proved to be both males, one of them having the testes very small, while in the other they were moderately developed. One of these specimens was 1 foot 7 inches, the other 1 foot 7½ inches in length.

Thus, in the course of December, 1888, and January and February, 1889, I collected several small living conger, which I believed to be males, and I kept these in a tank by themselves in order that they might sooner or later develop into a condition of sexual maturity. On March 7th I made an examination of this collection of males. There were eight specimens in all, in addition to the one which was found to be perfectly ripe on December 13th, 1888. The specimen when handled on March 7th, yielded extremely fluid milt, which under the microscope seemed quite healthy, and was full of active spermatozoa. But the specimen itself was considerably diseased; although it was lively and active when irritated, it had little strength. It was quite blind, one of its eyes being reduced to a loose red ulcerous mass, while the other was clouded and opaque all over the cornea. The skin was also abraded at one or two places on the body. These abrasions appeared as white patches which showed no signs of inflammation. Under the jaw were other abrasions, which were red and inflamed.

The other eight males were still unripe, none of them yielding milt when squeezed.

The ripe male discovered on December 13th, 1888, died in the aquarium on June 24th, 1889. It had taken no food since it was first found to be ripe on the former date, that is for a period of six months, and before its death had become very thin and feeble, and somewhat crooked as well as blind.

We have now to turn our attention to the history of the large females in the aquarium. Among these there was one which was distinguishable as early as December 17th, 1888, by her large size and by the somewhat distended appearance of the abdominal region. But at this time she was feeding voraciously. In March, 1889, I was told by the attendant that this conger had ceased to feed. Before that I had, with the help of the attendant, caught her in a sac fastened to a large hand-net and squeezed her, but had obtained no trace of eggs. On April 6th I fed the conger myself in order to verify the report that this specimen had ceased to feed, and found it was perfectly true. Never after that date did she take any food.

I carefully watched this female specimen, and occasionally squeezed her carefully after the same method as that already described. When I tried in June I could obtain no eggs from her; but on July 24th a few eggs were obtained by squeezing. These eggs were very small and were chalk-white in colour. Examined under the microscope, they were perfectly opaque, the vitellus being composed of numerous small spherules; there were no separate oil-globules, and the egg-membrane or envelope was everywhere in close

FIG. 3.—Egg of *Conger vulgaris* squeezed from gravid female July 24th, 1889. Drawn one hour after leaving the parent.

contact with the vitellus. The eggs sank to the bottom in a bottle of sea-water, density 1·027. An hour after extrusion a perivitelline space had developed between the enveloping membrane and the vitellus, as

shown in Fig. 1, but the latter was as opaque as before, and there was no indication of a germinal disc (blastodisc). The formation of the perivitelline space indicates that these eggs were almost ripe, but it does not follow that they had acquired the characters of the perfectly ripe eggs; it is quite possible, I think, that the eggs might become transparent and buoyant when perfectly ripe. The diameter of one of these eggs after the formation of the perivitelline space was 1·6 mm.

On July 25th I isolated this female specimen in a separate tank, and placed with her three small specimens identified as males, but the latter were not ripe and did not yield milt on squeezing. I observed no signs of sexual excitement in either female or males when they were thus placed together.

On August 13th I again squeezed the female but got no eggs. After she was released on this occasion it was found that her head was bent down at an angle with the body, and she appeared almost paralysed. Some injury had evidently been done to the vertebral column and spinal cord in the process of handling, but she continued to breathe and lived some time afterwards.

On the 14th and 15th I again tried to squeeze eggs from her, and obtained some separate ova and some small pieces of the ovary. No violence was used in the process, but the ovary is, when enlarged, very soft and tender, and pieces of it are therefore easily detached. The eggs obtained were in the same condition as those obtained in July, I could see no advance in their development; one of them measured ·95 mm. in diameter. A perivitelline space, in most eggs somewhat irregular in shape, was formed after extrusion as before, but the eggs were still without the appearance of perfectly ripe eggs.

This female died on September 10th, having then been without food since April 6th, that is five months at least; she had ceased to feed before that, and had therefore probably been fasting for six months. After her death the ovaries were found to weigh 7 lbs. 5 oz.

In the autumn of 1889 I collected some more male conger, in order to continue my experiments with other large females which were approaching maturity in the aquarium.

On January 24th, 1890, I removed from among the rest two large females which had ceased to feed for some time, and placed them with eight males in a tank from which all other animals had been removed. These males were all ripe or very nearly so, some of them having been ascertained to yield ripe milt when squeezed. Among these specimens unmistakable signs of sexual excitement were observed. The males were generally active and

restless, but seemed to take a good deal of notice of the females, frequently smelling at their genital apertures. The females rested on the gravel at the bottom of the tank, and constantly swayed from side to side so as to press the abdomen and genital aperture on the gravel. The smaller of the two females rested for days with its head in one of the corners of the tank, and one of the males for some days remained almost constantly by her side, his snout level with hers, his body in the angle between her body and the gravel, on her left side. While he was in this position I frequently noticed a rapid quivering vibration pass along his longitudinal fins, a motion quite different from that of the same fins when used in swimming or in hovering, and only suggestive of sexual excitement. I drove this male away once or twice with a stick, but after one or two digressions he invariably returned slowly to his former position beside the female. Sometimes the female made an excursion up and down the tank, and the male followed her. At other times the male would move away of his own accord, but after a short time would return to his former post beside the female.

While I was absent from the Laboratory in February, through illness, one of the males was taken out dead; it was exceedingly ripe, and was probably the one I saw with the female, for after this I saw no such constant association between a male and female.

On March 23rd I took out this smaller female and very carefully squeezed her abdomen; mucus and blood escaped from the genital aperture together with one free ovum. The ovum was, in all respects, similar to those obtained from the female that died in 1889. The escape of blood showed that the ovary was ruptured, although the squeezing had been performed very gently; probably, I think, the rupture had taken place before the squeezing. Next day this female was seen to be writhing about and lying on her side. Not long afterwards she was found to be dead. I squeezed her after death and obtained a number of free ova and small pieces of the ovary consisting of eggs fastened together by the scanty ovarian tissue. I placed these eggs in sea-water with some ripe milt from a male, and then kept them in a circulation of sea-water for some days. But though a perivitelline space was formed as before, I never saw any signs of the formation of a blastodisc or of segmentation.

The results of a post-mortem examination were as follows:—The ovaries together weighed 3 lbs. 4½ oz. The stomach was quite empty, its walls very thin, and containing numerous coiled-up parasitic nematodes or thread-worms. The intestine was very thin, containing only yellow mucus; the stomach and intestines were compressed into the smallest possible space by the enlarged ovaries. All the viscera, including liver and spleen, without the ovaries, weighed 8 oz.

14 dr. Length of the fish 4 feet $5\frac{1}{2}$ inches; total weight of fish, including everything, 16 lbs. 2 oz. 6 dr. It may be supposed that by taking out this female and squeezing her I caused her death and prevented the normal extrusion of the ova, but my subsequent experience shows that there is little probability in such a supposition.

It is interesting to compare the above weight and dimensions with those taken from a female which died of disease on February 24th, 1891. This specimen was 4 feet $8\frac{1}{2}$ inches in length, and weighed 22 lbs. 1 oz. The teeth and bones of the head were still normal, and the ovaries immature. In the latter under the microscope the largest eggs were found to be ·35 to ·45 mm. in diameter, and to be separated from one another by fat-cells; the eggs were perfectly opaque. The ovaries together weighed 2 lbs. The intestine, liver, and other viscera weighed 1 lb. 7 oz. The stomach and intestines, although containing no food, were evidently in a normal condition, not collapsed or reduced in size.

From this comparison it follows that the ovaries increase very much in size and weight during the fasting period at the expense of the rest of the body, while in the total weight of the fish a great reduction takes place. It is evident, therefore, that the nutrition of the developing ova consumes not only the fat in the ovary itself, but a large quantity of additional material drawn from the rest of the body.

The second of the two females placed with the males on January 24th died on April 22nd. For two days previously it seemed to be in travail, gasping and twisting itself about as if trying to get rid of its eggs. I expected to find the eggs riper than in the other specimen, but when it was opened I found them rather less developed; none were free, all firmly attached in the ovary; they measured ·97 mm. in diameter (1 mm. = $\frac{1}{25}$ inch). The length of the fish was 5 feet 11 inches, weight 28 lbs. 9 oz.; the two ovaries weighed 4 lbs. 5 oz. This specimen was never squeezed or handled in any way after its removal from one tank to another on January 24th, so that its death was not due to any mechanical injury.

On March 15th two other female congers which had ceased to feed were removed from the largest tank in the aquarium and placed in the tank where the males were. As it now seemed hopeless to expect any female to produce ripe eggs in the aquarium, I put these two with six ripe males in a box, and sank the box in ten fathoms of water in Plymouth Sound. I occasionally hauled up the box and examined the fish. On August 18th I found one of the females dead, but the other was alive and vigorous. The dead one measured 5 feet 4 inches in length. Its total weight was 33 lbs. 8 oz., of which the ovaries together weighed 7 lbs. $6\frac{1}{2}$ oz. By counting the

eggs in a grain of the ovary, I calculated the total number in the two ovaries to be 7,925,280. Thus the result of my calculation agrees closely with that made at the Southport Aquarium, and therefore the number obtained by Dr. Otto Hermes at Berlin was probably very much too small. The last female I have referred to had taken no food since March 15th, five months.

On August 30th I put the box containing the remaining female down in another part of the Sound, attaching the rope connected with it to the moorings of a buoy. Probably the motion of the buoy broke the rope, for the latter was recovered, but the box could never again be found. The eggs in the female which died in the box were in the same condition as those previously obtained from other females, and the problem of obtaining ripe fertilised eggs still remains unsolved.

When examining the ripe females that died in 1890 (three specimens) I noticed that they had lost nearly all the teeth, and that the bones of the head were soft and flexible. I afterwards made a careful comparison of two of the heads of these specimens preserved in spirit, with the fresh head of a conger bought on the fish-quay on January 6th, 1891. The latter specimen was 4 feet $5\frac{3}{4}$ inches in length, the total weight 14 lbs. $7\frac{1}{4}$ oz. I found the teeth in this specimen to be as follows:—They are all similar in shape, small, short, and obtusely pointed, and they are very numerous. In each jaw on each side there is one principal row situated on the narrow projecting edge of the jaw. These teeth are very close together, so that their points form a cutting edge. Along the inner side of the gums is a single row of smaller teeth, whose points project but slightly through the gums. At and near the anterior extremity of the premaxilla, on the outer side of the principal row of teeth, are other incomplete longitudinal rows, broadening out into a patch at the extremity of the bone. Similarly in the lower jaw there are incomplete rows on the outer side of the principal row, broadening out into a patch at the anterior extremity of the mandible. In the front of the upper jaw there is an oblong patch of teeth attached to the anterior part of the vomer. All these teeth are very sharp and strong, although small, and are very firmly fixed in the bones which bear them.

In the females which died with ripening ovaries there are only a few scattered teeth left; nearly all of them have disappeared. The few which remain are loose and blunt, held only by the skin, and not firmly fixed in the bones. The prominent ridges of the jaw-bones on which the principal rows of teeth are situated in the feeding conger have also disappeared, and the surface of the bones within the mouth are smooth and flat.

The condition of the bones of the head themselves in the conger which have died with ripening ovaries is still more remarkable. The bones are reduced in size, and are so soft and friable that they break easily in the fingers; they offer no resistance when bent, and can be cut with the finger-nail. In order to expose the teeth I cut down from the angles of the mouth with a large knife which was anything but sharp, and the knife cut straight through bones and tissues almost as if it were cutting cheese. In the head of the conger bought on the fish-quay it was impossible to cut through the bones; I had to find the joints, and use a good deal of force to separate the bones from one another.

I also examined the head of a ripe male, and found it was in the same condition, the teeth nearly all gone, the bones in a spongy and soft condition.

The reason of this is probably to be found in the fact that the breeding conger lives so long a time without food. No doubt much of the material of the body is absorbed into the blood and used up in the development of the ova, but probably some of the lime salts to which the bones owe their hardness are excreted.

In any case it is not to be wondered at, since tissues are always undergoing waste, that the bones should degenerate in a fish which takes no food for six months, and in which, further, a large weight of ova is developing at the expense of the rest of the body.

The following two tables give a synopsis of some numerical data related to the observations I have described.

TABLE I.—*Numerical data concerning Ripening Female Conger. Specimens examined by me at Plymouth.*

Date of death.	*Length.*	*Weight.*	*Weight of ovaries.*	*No. of eggs calculated.*
Sept. 10th, 1889 .	?	?	7 lbs. 5 oz.	
March 24th, 1890 .	4 ft. 5½ in.	16 lbs. 2⅝ oz.	3 lbs. 4½ oz.	
April 22nd, 1890 .	5 ft. 11 in.	28 lbs. 9 oz.	4 lbs. 5 oz.	
Aug. 18th, 1890 .	5 ft. 4 in.	33 lbs. 8 oz.	7 lbs. 6½ oz.	7,925,280
Recorded by Hermes.				
? .	?	22 lbs. 8 oz.	8 lbs.	3,300,000
Recorded by Day.				
June, 1876 .	?	15¼ lbs.	7 lbs.	6,336,512

TABLE II.—*Showing the Numerical Relation of the Sexes in Conger under 2 feet 6 inches in length, examined by me at Plymouth.*

Date.	*No. of specimens.*	*Males.*	*Females.*
November 17th, 1887	11	3	8
December 20th, 1887	1	0	1
June 6th, 1888	2	0	2
June 14th, 1888	2	1	1
July 4th, 1888	2	0	2
July 21st, 1888	3	0	3
December 7th, 1888	2	1	1
December 20th, 1888	2	2	0
January 2nd, 1889	6	2	4
January 3rd, 1889	3	2	1
	34	11	23

III. *Discussion of Results of my Observations.*

Some of the conclusions which I have drawn from my observations are certain and others are only probable. Perhaps the most interesting of those which are certain, is that the males are distinguishable from females of the same size by slight but constant secondary sexual characters. The most important of these is the shape of the snout previously described, but I have found the pigmentation of the abdomen to be also a constant difference. The prominence of the eyes I have only noticed in males which were actually ripe. Perhaps careful comparative measurement would have shown that the eye is always larger in the male than in the female, but pressure of other work has prevented me making such measurements.

The largest male I have seen was only 2 feet 2 inches long, $3\frac{3}{5}$ inches less than that described by Dr. Otto Hermes. I conclude, therefore, that the latter specimen was unusually large, and that 2 feet 6 inches is the extreme limit of length of male specimens. The smallest ripe male I have seen was the first one I obtained, which was only 18 inches in length.

As shown in the table No. 2, according to my experience, even among specimens under 2 feet 6 inches long, the proportion of males is not more than 33 per cent. Brock found males and females about equal in number among 45 specimens. I have only recorded 34 specimens in my note-book, although in collecting living males I examined a larger number. I conclude that the males are less numerous than the females, for it must be remembered that all specimens over 2 feet 6 inches in length are females, and, therefore,

if the sexes were approximately equal in number we should find the males more numerous than the females among the specimens under 2 feet 6 inches.

Another important conclusion I have drawn from my observations is that each conger only breeds once in its lifetime, or, in other words, that every specimen whether male or female dies after shedding its milt or ova. With regard to the males, I have shown that nothing is easier than to obtain them in the sexually ripe condition by keeping them in an aquarium until they ripen. Of the ripe males which I have had in captivity three have died. I never took out a dead male from the aquarium which was not ripe. Both males and females are very hardy, and during the time I have observed them in our aquarium only one specimen has died, excepting ripe males and females. The other ripe males which I had in 1890 were lost in the attempt to keep them in a box at the bottom of the sea. It may, of course, be argued that if the females were in natural conditions, and were able to extrude their ripe ova, they would again commence to feed and then breed again. We know that a considerable proportion of other animals die after breeding in consequence of exhaustion, although normally they produce young or eggs a great many times in succession. But, on the other hand, if the conger were able to recover in its normal free state in the sea, it is extremely unlikely that it would die so invariably in captivity, after attaining sexual maturity, especially considering that while its sexual organs are immature it is one of the hardiest, healthiest, and most voracious fishes in the aquarium.

Another objection which may be urged is the great variation in size among adult female conger. One of the gravid specimens which died in our aquarium was only 4 feet 5½ inches long, and just over 16 lbs. in weight, while the largest of those I have recorded was only 5 feet 4 inches long, and 33 lbs. 8 oz. in weight. And yet specimens are caught at sea which are much larger than this. Day, in his Fishes of Great Britain and Ireland, mentions one 6½ feet long, weighing 53 lbs., others weighing 84 lbs., 100 lbs., 104 lbs., and 112 lbs., and one measuring 8 feet 3 inches, and weighing 128 lbs. But this by no means invalidates my conclusion, for fishes of the same age vary wonderfully in size, as I know from flounders of the same age which I have myself reared in our aquarium. It is probable enough that the age at which in the female conger feeding and growth ceases, and the maturation of the ova begins, may vary in different individuals. It is also all but certain that females of the same age will reach very different sizes, some obtaining more food than others; even where the same supply of food exists, some probably are less voracious, and have less power of assimilation than others. Butter-

flies of a given species, although they breed only once, exhibit considerable variation in size.

The strongest evidence, however, in support of my conclusion is, I think, the loss of the teeth and the atrophy of the bones, which occurs during the ripening of the sexual organs. A conger, after it had shed its milt or ova, would in all probability be entirely incapable of feeding itself; without teeth it would be unable to hold its prey, and without food it could not recover its former condition.

Cases of animals dying after breeding once are, of course, not uncommon in the animal, any more than in the vegetable kingdom. Among insects it is rather the rule than the exception. But confining ourselves to the Vertebrata, to which the conger belongs, there are in that class cases of the phenomenon which are well established. The common eel is known to go down to the sea in order to breed, and the young elvers ascend the rivers in spring in countless multitudes, but no adults have ever been known to return. It is very probable that it will ultimately be found that all the members of the eel family (Murænidæ) produce eggs only at the cost of their own lives. Among the Cyclostomata my own investigations have shown conclusively that the hag-fish, *Myxine*, does not die after breeding. It breeds again and again, for I have taken, both on hooks and in baited traps, numbers of females with ovaries showing the collapsed follicles, from which the eggs had been recently discharged. In fact, in an old female *Myxine*, the *corpora lutea*, *i. e.* the old empty follicles in different stages of atrophy, belonging to successively discharged crops of eggs, can always be seen in the ovary. On the other hand, the river lamprey, *Petromyzon planeri*, has been shown to die after breeding once. In this last case there is a true metamorphosis from a sexually immature larva, the Ammocœtes, which feeds and grows, to the sexually mature adult, which feeds little or not at all, breeds, and then dies.

With regard to the season of the year at which the spawning of the conger takes place, my observations tend to show that it is not confined to a very short period, but extends over several months. It is impossible to decide how long a period would have elapsed before each of the ripening females I have mentioned shed its ova, if it had lived to do so. If we suppose that another month was required to bring the ova to perfect maturity, then the ova would have been shed in April, May, September, and October. Similarly the female which was observed at Southport would, perhaps, have spawned in July; whence it may be provisionally inferred that the female conger spawns in summer and autumn from about April to October. But, on the other hand, I have had ripe males in my possession from December to the end of August. If

we infer from this that some females also become sexually ripe during the same period, then the spawning season is extended from December till October, eleven months in the year. If this inference is correct it becomes very improbable that the month of November should alone be excluded, and thus there is some ground for the conclusion that conger spawn at any season of the year. I shall have to refer to this question again before the end of this paper. It is at least certain that actually ripe males, or gravid females, have been observed in every month of the year except October and November.

The observed fact that both males and females cease to feed when their sexual organs begin to ripen, satisfactorily explains why it is that ripe specimens have never been obtained directly from the sea, but have only been found among conger kept for some time in captivity. For conger are usually caught by baited hooks, and of course can only be captured in that way when they seek their food. Occasionally they are taken in lobster pots, but they enter these also for the sake of the bait. Conger are frequently taken in the beam trawl, but as the gravid females in aquaria lurk constantly in holes and corners, it may reasonably be supposed that in the sea they remain in their hiding-places among the rocks, and that only those which are hunting for prey can ever be captured by the trawl.

The largest ova I have seen in newly-captured conger were ·7 mm. in diameter; these occurred in a specimen examined in March. In other large specimens the ova varied from ·2 to ·5 mm. in diameter. The larger the ova in such specimens taken directly from the sea the smaller the amount of fat-tissue; when the ova are small the fat forms the greater part of the mass of the ovary, but in more fully-developed ovaries the mass of the ova exceeds that of the fat. In the gravid females which died in the aquarium the ova when first shed were ·95 to a little over 1 mm. in diameter, and fat was entirely absent from the ovary. It is evident that the fat is deposited at first in the growing ovary in very great quantity, and is afterwards used up for the nutrition of the developing ova. Much of the fat is reabsorbed in this way before the female ceases to feed; the rest is exhausted during the period of fasting. The difference in size between the largest ova observed in conger from the sea, ·7 mm., and the ova of the gravid females from the aquarium, about 1 mm. before the formation of the perivitelline space, may seem small, considering that the ova of the gravid females have been developing for five or six months after the cessation of feeding. But in the feeding conger the large eggs are comparatively few, the rest are of all sizes, and the majority of them are quite undeveloped. In the gravid females all the eggs are of about the same size, so

that the fasting period is devoted not so much to the increase in size of the few large eggs in the ovary, as to the development of the vast numbers of very young eggs which the immature ovary contains.

It was erroneously stated recently in *Nature** that a German naturalist had obtained a conger at Zanzibar containing eggs which were 2·5 mm. in diameter. I found that this statement was founded on a short paper published in the *Zoologischer Anzeiger*, 1890, p. 314, by a Dr. Voeltzkow, describing a gravid specimen, not of *Conger*, but of some species of *Muræna*. This specimen contained eggs which were 2·5 mm. in diameter and transparent. But the writer in *Nature* had misquoted the paper to which he alluded, and had written *Conger* instead of *Muræna*. The specimen of *Muræna* in question was probably more advanced towards sexual maturity than any conger yet described, because its eggs were transparent, and escaped on slight pressure from the genital aperture. But I have not been able to find any description of a female conger containing eggs larger than those described by me in this paper.

IV. *The Eggs of the Conger after Deposition.*

My own work has been confined to the study of the adult conger, my efforts having been directed towards the elucidation of the reproduction as the most satisfactory foundation for a future investigation of the development of the fish from the eggs. But there are a number of facts and probabilities concerning sundry stages of the development of the conger which have resulted from occasional observations made from time to time by other naturalists, and I think it will increase the interest of this paper if I add here a brief review of these.

To take the stages in order, we will begin with what is known of the eggs of the conger after they have been deposited by the female and been fertilised. No such developing eggs have yet been identified with certainty. It seems probable in the first place that the eggs are pelagic, that is buoyant and transparent, and each suspended separately and freely during development in the sea-water. One reason for supposing this is that eggs of the vast majority of truly marine fishes are pelagic. The eggs I have seen in gravid female conger are quite opaque and not buoyant; but these were not perfectly ripe, and it is usually the case that pelagic eggs in the ovary are opaque and heavier than sea-water up to the very last period of their maturation. In fact the eggs in an ovary (*e. g.* that of the sole) ripen in succession,

* See *Nature*, vol. xlii, p. 654, 1890.

and while a few are mature and transparent the rest are still opaque. Therefore it would not be at all surprising if the eggs of the conger were transparent and buoyant when perfectly mature and ready for fertilisation. This probability is made almost a certainty by the observation by Voeltzkow, already cited, on the ripe ova in a specimen of *Muræna* found at Zanzibar. The eggs in this case were perfectly transparent, and, therefore, probably after fertilisation would be pelagic.

The Italian naturalist Raffaele in his valuable paper on the *Pelagic Eggs and Larvæ of Fishes occurring in the Gulf of Naples*,* published in 1888, described five different kinds of pelagic eggs, which all resembled one another in certain common characters, and which could not be traced with certainty to the parent fish. Raffaele thinks it possible that these eggs belong to various species of the eel family (Murænidæ). He bases this suggestion on the form of the body, the form of the head, and the large number of muscular segments in the larvæ hatched from the eggs. The eggs all agree in having an extremely large perivitelline space, like that of the pilchard's egg, and in the fact that the yolk is not homogeneous but made up of separate vesicles, also like that of the pilchard. This similarity to the eggs of the pilchard is an important matter. For the family Clupeidæ is the only one among the Physostomi hitherto known to include species with pelagic eggs, and these eggs are distinguished from the eggs of Physoclisti by the two characters above mentioned. Therefore it is in the highest degree probable that Raffaele's eggs belong to some family of the Physostomi, and the Murænidæ is the only family among these in Europe whose eggs are not known.

We may consider it, then, as all but proved that the eggs of the Murænidæ are pelagic, and that to Raffaele belongs the credit of discovering them. In size the eggs described by Raffaele agree very well with those of the conger which I have measured. Unfortunately he only gives the diameter of the actual ovum inside the capsule in one case, in which it was 1·2 to 1·3 mm., scarcely larger than the unripe ova of the conger measured by me before the formation of the perivitelline space. The diameter of the external capsule in Raffaele's eggs was 2 to 3 mm., all the five kinds, except one, having a varying number of oil globules. I am not sure that the egg of the conger when ripe is without oil globules, but so far as I could judge it is so. In this case the egg without oil globules among those described by Raffaele is probably that of *Conger vulgaris*. The larvæ hatched from these eggs were, as I have said, all very similar. Besides the large number of body segments, they all agreed

* Mitt. Zool. Stat. Neap., Bnd. viii.

in the development, shortly after hatching, of peculiar long teeth in the jaws. After the fifth day from hatching the larvæ all died.

V. *The Larva of the Conger.*

The larval conger has been identified with certainty at a later stage, a transparent peculiar fish, whose nature remained for a long time doubtful, having been recently proved to be the young of the conger.

The history of our knowledge of this stage of the larva is somewhat curious, and I will therefore give a comprehensive summary of it. About the year 1763 a specimen of an unknown transparent fish of small size was captured in the sea near Holyhead by a gentlemen named William Morris, by whom it was given to Pennant, a celebrated zoologist of the last century. Pennant sent it to Lawrence Theodore Gronow, a Dutch ichthyologist living at Leyden, and the latter published a description and figure of it in the first part, issued in 1763, of a work entitled *Zoophylacium.* Gronow or Gronovius, for he wrote his scientific works in Latin, gave the fish the name *Leptocephalus.* Pennant himself gave a description and figure in all respects similar to those of Gronovius in his *British Zoology,* vol. iii, published in 1769. Pennant calls the fish the Morris after the name of its discoverer, and *Leptocephalus* after Gronow. His definition is: "Small head, body extremely thin, compressed sideways; no pectoral fins." His description is to the following effect:—"The length was 4 inches, head very small, the body compressed sideways, extremely thin and almost transparent, about $\frac{1}{10}$th inch thick, and in the deepest part about $\frac{1}{3}$rd inch in depth, towards the tail the body grew more slender and ended in a point; towards the head it sloped down, the head lying far beneath the level of the back. Eyes large, teeth in both jaws very small. Lateral line straight, sides marked with oblique strokes that met at the lateral line. Aperture to gills large. It wanted the pectoral, ventral, and caudal fins; dorsal fin extremely low and thin, extending the whole length of the back very near the tail. Anal fin of the same delicacy and extending to the same distance from the anus."

In the later edition of the *British Zoology* of Pennant, which I have not seen, mention is made of the capture of other specimens of the *Leptocephalus,* one gentleman, a Mr. Hugh Davies, having seen four specimens, three of which were taken in the amusement of prawning below Beaumaris Green. But I believe no improvement of, or addition to, the description was made in this edition.

The next account from an actual observer which I have seen is that of Colonel Montagu in the Memoirs of the Wernerian Natural History Society vol. ii, 1818. This naturalist says he possessed two specimens taken by Mr. Anstice, of Bridgewater, in the river Pervet, one in 1810, the other in 1811. Both were caught in a hand-net near the surface of the water. Montagu says that Pennant's description is wrong in stating that pectoral and caudal fins were absent. He says his largest specimen was 6 inches long, $\frac{1}{2}$ inch broad, $\frac{1}{16}$th inch thick; jaws equal in length, teeth numerous and all inclining forwards. Dorsal fin does not extend the whole length of the back as Pennant stated, but commences one third the length of the body from the snout. Pectorals very minute. Pennant's description also omits mention of the minute black specks on the margin of the back and belly.

In Gmelin's edition of Linnæus's *Systema Naturæ*, 1788, the fish as described by Gronovius had been introduced under the binomial name *Leptocephalus Morrisii*, and this name is used by Montagu. In all probability Montagu is right in believing that Pennant's fish and his own were the same, and that Pennant's description and figure were erroneous. Montagu's description and figure have been shown by subsequent observers to be correct, and it is therefore rather from him than from Pennant that we should date our knowledge of the form which he calls *Leptocephalus Morrisii.*

In Loudon's Magazine of Natural History, vol. v, 1832, p. 313, there is a description from actual observation by R. Couch, the Cornish ichthyologist, of a fish which he calls *Ophidium pellucidum*, but which he says, in a second communication in the same volume, is undoubtedly the same as the *Leptocephalus Morrisii* of Fleming's British Animals. Fleming's account is simply taken from that of Montagu. Couch says he had seen four specimens and gives the length (presumably of the largest) as $5\frac{1}{2}$ inches, depth $\frac{1}{2}$ inch. There are only one or two points in which this description by Couch does not agree with that of Montagu. One is that the former does not mention the lateral compression of the fish, although he refers to its great transparency. Another is the statement that one specimen differed from the others in having two bifid teeth projecting forward from the under jaw; in proportion to the size of the fish they might be termed tusks. If we compare this statement with Raffaele's description of the teeth in the larvæ hatched from his unidentified pelagic eggs, we are at once led to conclude that the teeth observed by Couch were the remains of the more prominent and more numerous teeth of a still earlier stage of the conger larva, and Couch's observation confirms the hypothesis that Raffaele's eggs are those of the Murænidæ.

In 1833 another specimen of the *Leptocephalus Morrisii* was described in Loudon's Magazine (vol. vi, p. 530). The observer in this case was Mr. Henry Vietz Deere, of Slapton, Devon, who states that on April 29th, 1833, one of the local fishermen brought to him a small fish apparently dead, which he had carried in his pocket for three hours wrapped in a piece of brown paper. Nevertheless, the fish seemed to be alive, and was therefore placed in a tumbler of salt and water, where it lived for some hours. Mr. Deere identified his specimen as the *Leptocephalus* of Pennant, being unacquainted with other descriptions, and, like Montagu, he proceeds to correct Pallas's description. He says the body was $5\frac{1}{2}$ inches in length, $\frac{1}{8}$ inch thick, $\frac{7}{16}$ inch deep from back to belly. It was compressed laterally in a remarkable manner, and was pellucid, bright, and silvery. The head was small, $\frac{1}{4}$ inch long, but straight with the line of the back. The dorsal fin did not extend the whole length of the back, as Pennant said, but commenced $2\frac{1}{2}$ inches from the snout, and the pectoral fins were present, though small. Deere thought the fish to be allied to the launce, *Ammodytes tobianus.*

Yarrell's description in his *British Fishes*, 1st ed., 1836, is based on three specimens which he received from Couch ; he does not add anything essential to previous accounts ; he says it is usually found among seaweed.

Couch's description in vol. iv of his *Fishes of the British Islands*, 1865, is not very instructive, but he gives a good figure, which was doubtless drawn from one of his own specimens. It is a pity he does not say more about the habits and habitat of the fish. He merely says that its usual residence is in shallow water and rocky ground, but it also inhabits the deeper water.

Off the shores of England only this one kind of *Leptocephalus* has been found, but in the Mediterranean several species are defined by Kaup (*Apodal Fish*, Lond., 1856–8, and *On Some New Genera and Species of Fishes*, Ann. Mag. Nat. Hist., vol. vi, 1860). In the latter paper Kaup identifies the *L. Spallanzani* of Risso's *Hist. Nat. de l'Europe Meridionale* with the *Leptocephalus Morrisii*, and says that specimens vary in the development of the teeth, which are sometimes absent, and that in some the tail is longer than the body, in others *vice versâ.* He says that the species is common at Messina, where it lives in the open sea, not in the seaweed, and is caught in bottles by boys when bathing.

Prof. J. V. Carus was the first, in a pamphlet entitled *Ueber die Leptocephaliden*, Leipzig, 1861, to suggest that *Leptocephalus* and allied forms were the larvæ of other fishes ; he concluded that *Leptocephalus* was the larva of *Cepola*, a genus of rather small,

laterally compressed fishes, one of which, *Cepola rubescens*, is British.

But the identification of *Leptocephalus* with *Cepola* was obviously erroneous on anatomical grounds, and was completely rejected by other zoologists. An American ichthyologist, Gill, after examining the subject, came to the conclusion (Proc. Acad. Nat. Sc. Philadelphia, 1864) that the typical *Leptocephali* were the young of congers, and the one considered here, *Leptocephalus Morrisii*, the young of *Conger vulgaris*; he referred *Hyoprorus*, another genus of the Leptocephalidæ, to another genus of the Murænidæ, namely, *Nettastoma*, which lives in the Mediterranean.

Gill did not give the anatomical comparisons on which his conclusions were based. In his British Museum *Catalogue of Fishes*, vol. viii, 1870, Dr. Günther confirms Gill's conclusion so far as concerns the derivation of *Leptocephalus Morrisii* from the conger, but doubts whether the conger is developed from the *Leptocephalus*. Dr. Günther mentions as evidence for the connection between the two forms, the similarity in the form of the head and its parts, the coincidence in the number of vertebræ (156) and the geographical distribution. But he says the question arises whether the *Leptocephalus* is a normal stage in the development of the conger, or whether it is an individual arrested in its development at a very early period, yet continuing to grow to a certain size without a corresponding development of its internal organs, and destined to perish without attaining the characters of the perfect animal.

The reasons Dr. Günther gives for the latter view are three:—(1) That he has seen a specimen of a conger 4½ inches long, *i.e.* smaller than numerous specimens of *Leptocephalus Morrisii*. (2) Specimens showing apparently a more developed condition, an approach towards the conger, in the more cylindrical body and more elongated snout, nevertheless have still an undeveloped vertebral column; if *Leptocephali* are abnormally undeveloped forms, some individuals may be more developed than others in certain points. (3) The variations in the form of the body, dentition, &c., are so great that it is impossible to separate them into specific forms, and this great variability favours the supposition that they are individuals abnormally arrested in their development.

This hypothesis concerning *Leptocephali* is still more confidently maintained in Günther's *Introduction to the Study of Fishes*, published in 1880. The same hypothesis has been put forward in two other cases, namely, in that of the large *Phyllosoma* forms, known to be derived from the Loricate Crustaceans, such as *Palinurus*, and in that of large *Tornariæ*, known to be the larvæ of *Balanoglossus*. In the case of the *Tornaria* it was found on investigation that the

larger specimens were the younger, and that the metamorphosis into *Balanoglossus* was accompanied by a considerable reduction in size. Such a reduction in size is, in fact, a very common feature in metamorphosis. I have found that the larval symmetrical flounder is considerably longer than the metamorphosed asymmetrical fish. It seems to me that the theory of an abnormal continued growth of larvæ, with arrested development, is at present entirely unsupported by evidence, and in any particular case can only be proved by the actual demonstration of the normal development and of the abnormal, together with proof that they are independent of one another.

However, to return to the case of the conger, I find that the French ichthyologist, Dr. Emile Moreau, in his *Poissons de la France*, tome iii, p. 568, claims to have satisfied himself by anatomical investigation that the *Leptocephalus Morrisii* is the young *Conger vulgaris*. Moreau does not refer to any publication of his anatomical researches, or even mention that he ever published his conclusion in any other place than that I refer to, but he states that M. Dareste appropriated his results in a *Note sur le Leptocéphale de Spallanzani* in the Comptes Rendus, tome lxxvi, 1873, p. 1304. Moreau asserts that Dareste examined his preparations of *Leptocephalus* and conger, but made no dissections himself.

If the evidence went no further than this, the conclusion that *Leptocephalus Morrisii* was the larval conger would rest merely on anatomical and zoological resemblances between the two forms. If it had been discovered that the *Leptocephalus* was developed from the eggs of the conger, proof would still be wanting that the former was a normal stage in the development of the latter, and Günther's theory of the abnormal growth of the larva would remain uncontradicted by observed facts. But the metamorphosis of a *Leptocephalus Morrisii* into a normal conger has actually been once observed. This observation was made by the distinguished French zoologist, Yves Delage, and is described briefly in the *Comptes Rendus*, tome ciii, 1886, p. 698. The particulars are as follows:— Two specimens of *Leptocephalus* were captured on February 7th, 1886, by the keeper of the Laboratory of Roscoff, in Normandy. One of them was damaged, and was preserved in alcohol The other was uninjured, and was kept alive in a tank of sea water. Unfortunately Delage, strange to say, omits to give the dimensions of these two specimens. On April 18th the living Leptocephalus was still ribbon-shaped and absolutely transparent, all its blood was colourless, and the air-bladder was not visible. On May 1st the skin began to get a little dark, the air-bladder appeared in the form of a silvery streak, the gills began to show a pink colouration. On May 9th the fish was examined alive under the

microscope for a few moments, with such care that its health was not imperilled. It was found that the dorsal fin extended a little in front of the posterior extremity of the pectorals; in the skin scattered black chromatophores were seen, which gave it its general smoky tint; the blood contained chiefly colourless corpuscles. In the tail were seen colonies of red corpuscles, motionless, and unconnected with the blood-vessels. Little by little after this date the body became more cylindrical, the head grew proportionately larger and more square in shape, and at the commencement of July the transformation was complete, the *Leptocephalus*, originally ribbon-shaped and transparent, with a small head, had become a small conger, opaque and coloured, with a cylindrical body and a head like that of the adult conger. The young conger in July, at the completion of the transformation, was 9·3 cm. ($3\frac{7}{10}$ in.) in length. The specimen died from accident on September 5th, and it was then preserved and, together with the other larva preserved in February, presented to the Academy. Delage adds that the *Leptocephalus* is hatched below the limit of low water, and usually is not found on the shore until after its transformation. He says that it is devoured by the pollack (*Gadus pollachius*), in the stomach of which it is frequently found.

I will add here one or two remarks concerning Günther's arguments. He states in the Catalogue that he has seen a *Leptocephalus* 10 inches in length, but does not say it was a *Leptocephalus Morrisii*. We have seen that the maximum length of English specimens recorded is 6 inches. Of twelve specimens from Messina, whose measurements are given by Kaup, the longest is $5\frac{1}{3}$ inches (134 mm.), the smallest $4\frac{1}{5}$ inches. Again, Günther's theory supposes that the abnormal development is due to the fact that the ova and larvæ, which normally develop in the vicinity of the shore, have been carried out to sea far away from land. But we have seen that the *Leptocephali* captured in England and at Messina have been taken in shallow water near shore, and not in the open sea far from land.

I have found that young conger under 15 inches in length are usually not black or dark like the adults, but pink in colour. I believe this to be due, not to specially coloured pigment cells, but to the small number of black chromatophores which are present in the skin, and which are not sufficient to conceal the natural colour of the tissues of the skin. The smallest of such conger in my collection is $8\frac{2}{5}$ inches in length (21 cm.), and was taken in the beam trawl off St. Agnes Head, on the north coast of Cornwall, April 14th, 1890. Judging from the observation of Delage, this specimen was about a year and a half old, having been a *Leptocephalus* in the preceding spring, 1889, and hatched in the autumn of 1888.

It must be remembered that the young of the common eel, although not so different from the adult as the larva of the conger, is nevertheless perfectly transparent up to a length of about 3 inches, a length fairly corresponding to 6 inches in the case of the conger. These young eels or elvers are common enough in Plymouth Sound in spring from February to May or June, or even later. Unlike the *Leptocephalus*, they resemble the adult eel in shape, the body being cylindrical, the head like that of the adult, having the lower jaw prolonged, and the pectoral fins well developed. They also have red blood, visible as a small red spot at the throat, which is really the heart, the eyes are perfectly black, and there is a line of black pigment along the spinal cord; otherwise they are transparent as glass. They are often found in tide pools and under stones at low tide, and are caught without much difficulty with the hand.

I regret to say I have not met with any specimens of the *Leptocephalus* at Plymouth, and if any reader of this Journal can present me with some, alive or preserved, I shall be very thankful.

The Head Kidney of Teleostean Fishes.

By

W. L. Calderwood.

With Plate I.

Until the year 1881, when Balfour wrote on the subject,* the pronephros was generally believed to be a functional kidney, not only in the larval condition, but also in those adult forms described as possessing the organ.

Balfour, in his more detailed paper, published later,† states that in the fishes examined—pike, eel, smelt, and angler—although the pronephros had all the appearance, externally, of a true functional kidney, no uriniferous tubules were present, and that a minute examination only disclosed a degenerate trabecular tissue which he describes as lymphatic.

The angler (Lophius), it may be observed, is generally considered to possess only a head kidney. This organ Balfour found to be in a perfectly functional condition, but he declines to believe that it is a persistent head kidney, and argues from the highly modified structure of the fish that the organ in question is in reality the mesonephros shifted forward from its normal position. He also maintains that in adult Ganoids the head kidney has no longer a renal function. His general conclusion, therefore, is, that since the pronephros was only supposed to persist in Ganoids and Teleosteans, it must be now considered as non-existent except in the embryonic or larval conditions.

Parker‡ also supports the conclusions of Balfour by stating that in many instances the mesonephros has grown forward in front of the air-bladder and taken the place of the pronephros.

* *The Pronephros of Teleosteans and Ganoids*, Brit. Assoc. Reports, 1881, p. 721.

† Quart. Journ. Micros. Science, January, 1882.

‡ *On the Kidneys of Teleosteans*, Brit. Assoc. Report, 1882, p. 577.

When studying the extraordinary position of the air-bladder in Dactylopterus volitans* I was struck by the very pronounced head kidney, and by its peculiar position. In this fish the pronephros is entirely separated from the body kidney and is situated anterior to the abdominal cavity in the same transverse plane as the heart. In the paper referred to it is shown that the swimming bladder of Dactylopterus is divided, on each side, into two main portions, one large and muscular, the other thin-walled but surrounded by bone and situated above and anterior to the muscular portion. Below this secondary portion, and in front of the primary, there is a cavity of inverted pyramidal shape, formed entirely of bone except on the anterior aspect.

The pronephros fills this cavity, its anterior surface coming in contact with the extremely vascular membrane lining the posterior portion of the branchial chamber.

The body kidney is situated behind the large muscular portion of the swimming bladder, and receives in a concavity the rounded posterior end of the bladder.

Communication between the two is, however, maintained by a canal formed in the ventral surfaces of the anchylosed first four vertebræ of the spinal column. This canal tunnels through what would otherwise be the bases of the transverse processes, and so is protected from any movements of the bladder which surrounds, and lies largely above the spinal column in this region.

The appearance of the pronephros when sectioned is represented in fig. 1. It is apparently a functional kidney. Sections of the body kidney give an exactly similar appearance, only in the majority of sections a greater number of uriniferous tubules are present, and no doubt this organ is capable of secreting more urine than the other. In comparing the organs, I took at random, ten sections from slides of head kidney sections, and ten from slides of body kidney, and used a lens with a wide angle (Zeiss D). I counted 87 sectioned tubules for the head kidney, and 144 for the body kidney; *i. e.* a majority of 57 for the body kidney.

This difference between the two organs may go to show that in Dactylopterus the degeneration of the pronephros is only commencing, but I think the conditions justify me in believing the organ to have a renal function.

In attempting to follow the course of degeneration I examined *Cyclopterus lumpus*. Here the pronephros, although joined to the mesonephros, is yet easily distinguishable from it. The single body kidney somewhat resembles an elongated cone in form, the apex

* *On the Swimming Bladder and Flying Powers of Dactylopterus volitans*, Proc. Roy. Soc. Edin., vol. xvii, 1890.

being posterior. At its broadest or anterior end it suddenly divides, each branch becoming constricted and then again dilating to form the large head kidney. The appearance of sections taken at this constricted part in no way differs from that of the body kidney proper, but in the fully-grown adult, the part where the dilatation to the head kidney begins shows an altered condition; uriniferous tubules have become fewer in number, blood-vessels have disappeared, and the cells of the surrounding matrix seem to have multiplied. Still further forward, hardly any trace of tubules remains. This condition is shown in fig. 2.

Here, elongated empty spaces alone denote the former position of tubules, and the granular matrix forms almost the entire organ; whereas in sections of the body kidney, the convoluted tubules lie so thickly together as to leave room for little surrounding substance. As to the nature of this matrix, which Balfour considers to be lymph, I am not prepared to make a positive statement. Looked at with a very high power, the granules are seen to be nucleated, and to possess a more or less irregular outline, but they are extremely small, and it seems to me the entire organ presents a singularly solid mass to be analagous to a lymph gland. Capillaries do not appear to exist, nor can I find any adenoid reticulum.

The very early condition of the pronephros is seen in fig. 3—a thirteen days' embryo. Here the tubules are still few in number, but large in proportion to the size of the organ, and there is a considerable mass of granular tissue. As development proceeds the tubules multiply, and there is consequently less granular substance, but a Cyclopterus three quarters of an inch long shows little difference in the condition of its pronephros, from the figure of the thirteenth day embryo.

I have preserved almost a complete series of specimens from the fertilization of the egg onwards, but find that not till Cyclopterus has become sexually mature does its head kidney commence to degenerate. Fig. 4 shows a section of the pronephros of what may be described as a half grown or small adult fish, but owing to the specimen having been preserved in strong spirit, great shrinkage has taken place. This figure is in strong contrast to the condition in the old fish as seen in fig. 2, yet it is very similar to the figure showing the old state in Dactylopterus, fig. 1.

Returning now to the statement of Balfour that, in some instances, the mesonephros grows forward so as to take up the position formerly occupied by the pronephros, and again considering the case of Dactylopterus, two objections suggest themselves. First, in the developing embryo, the segmental duct and pronephros are developed at a much earlier period than the mesonephros, and must be

permanently separated from all abdominal viscera before the completion of the mesonephros. Second, from the manner in which the head kidney is encased in bone, it appears that if what I am naming head kidney is in reality a part of the body kidney grown forwards (since it is functional), it must, to have taken up its position in the head, have penetrated both the air-bladder and the scapular arch.

Again, does the similar condition of the pronephros in a small adult Cyclopterus and an old adult Dactylopterus, not indicate that in some fishes (*e. g.* Dactylopterus) the degeneration of the organ in question has not yet reached that point demonstrable in many? This seems to me to be a more natural view than to suppose that any functional kidney occupying a position in the head is merely the whole or part of the true body kidney translated from its normal position.

If, then, I establish the fact that the head kidney in Dactylopterus is in reality a functional pronephros persisting in the adult, the statement of Balfour that such an organ does not exist must be modified, and a compromise made between it and the older hypothesis of Rosenberg, who first demonstrated that the head kidney was the persistent pronephros.

I think the above evidence, therefore, favours the conclusion that in adult Teleosteans the renal function is performed in some instances by the body kidney only; in others by the head kidney only; and in others—probably a very limited number—by both the body and head kidneys. Besides Dactylopterus, I am aware of only one instance where the head kidney is described as possessing tubules and Malpighian bodies, viz. in Fierasfer. (Carlo Emery, Le Specie del Genere Fierasfer nel Golfo di Napoli, Leipzig, 1880).

EXPLANATION OF PLATE I.

Illustrating Mr. Calderwood's paper on "The Head Kidney of Teleostean Fishes."

FIG. 1.—Transverse section of head kidney of an adult Dactylopterus. Zeiss' D, oc. 2.

FIG. 2.—Transverse section of head kidney of adult Cyclopterus. Zeiss' D, oc. 2.

FIG. 3.—Longitudinal section of pronephros of Cyclopterus embryo at thirteenth day. Zeiss' D, oc. 2.

FIG. 4.—Transverse section of head kidney of young adult Cyclopterus. From spirit specimen. Zeiss' D, oc. 2.

Fig. 1.

Fig. 2.

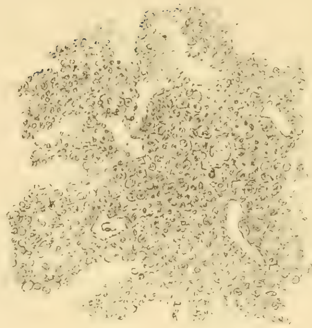


Fig. 3.

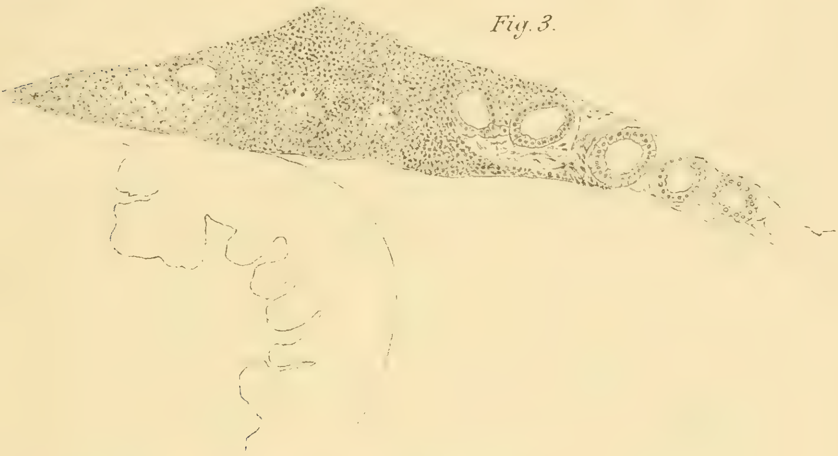
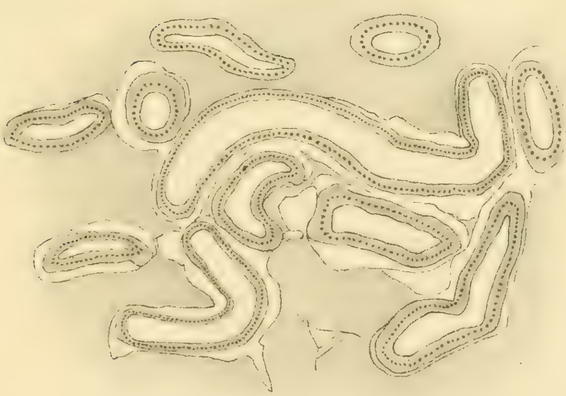


Fig. 4.



W. L. Calderwood del. F. Huth, Lith.r Edin.r

Report on the Tunicata of Plymouth.

By

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Jesus College, Oxford;
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With Plate II.

Part I.—CLAVELINIDÆ, PEROPHORIDÆ, DIAZONIDÆ.

The southern shores of the English Channel have long been famous for the wealth of their Tunicate fauna, having furnished material in abundance for the classical researches of Milne-Edwards, Giard, and Lacaze-Duthiers. The Channel Islands also have been repeatedly visited by English zoologists, and have amply supplied those among them who have been in search of Tunicate treasures. Probably the peculiar tidal conditions of this part of the Channel are especially favourable to a rich development of littoral forms; but, as the work of Montagu, Couch, Clark, Alder, Gosse, Cocks, Bate, and Norman sufficiently testifies, the Devon and Cornish coasts of England can lay claim to an almost equally luxuriant shore fauna, the rocky bays and long sheltered estuaries being especially wealthy in this respect. During my residence at Plymouth I found that the Tunicata were among the best represented groups of the fauna, and, as I devoted considerable attention to the search for rare or new, as well as for well-known forms, I trust that a classified report upon the local representatives of the group will not be without its usefulness to other investigators.

The absence of any work at all approaching the character of a monograph of the British Tunicata is a serious want which has long been felt by marine zoologists generally. Such a work has several times been commenced by some of our most eminent

naturalists, by Forbes and Goodsir, by Alder and Hancock, and by Professor Huxley; but various causes have hitherto conspired to delay its production. It is now very satisfactory to be assured that the preparation of the Monograph is in the hands of the experienced author of the Reports on the "Challenger" Tunicata. In the meantime a more or less detailed account of the forms with which I have met at Plymouth may be of some service as a contribution towards an improved knowledge of the British representatives of the group.

In the neighbourhood of Plymouth I found the rocks under the Hoe, the north and east sides of Drake's Island, the wooden piles of the docks and wharves in Millbay and the Cattewater, the rocks and tidal pools of the Mewstone and Wembury Bay, to be all good hunting-grounds for the littoral species of composite Tunicata; the best dredging-grounds for Ascidians generally were undoubtedly the neighbourhood of the Duke Rock, the Queen's Grounds, and the deeper waters off the Eddystone, the Mewstone, and Bigbury Bay, while some forms were most common upon *Zostera* in Cawsand Bay; but it was almost impossible to use any of the ordinary methods of collecting within Plymouth Sound without obtaining numbers of Ascidians of various species. Very few simple Ascidians were to be found inhabiting the tidal zone; they were most plentiful in the deep water of the trawling grounds and on the rough ground off the Mewstone.

In reporting upon the Ascidians of Plymouth, I have taken *Clavelina* and its allies as my starting-point, since this genus includes the forms which are in many respects probably the least modified descendants of the earliest Ascidiacea. But I am met at the outset by the problem which is now engaging the attention of every Ascidiologist: What taxonomical value must be attributed to the possession of the power of budding and of the formation of colonies? A full discussion of this question I cannot give here, but since the matter bears directly upon the classification which I shall employ, I am bound to admit that the division of the Ascidiacea into the sub-orders *Ascidiæ simplices*, *Ascidiæ compositæ*, and *Ascidiæ salpiformes* so completely disregards the admitted inter-relationship between various sections of these groups, that its adoption seems to me to involve the rejection of any morphological, and therefore genetic, meaning in classification altogether. The term "composite Ascidians" is in practice a very convenient one, but this is not a sufficient reason for retaining it as the symbol of a natural group, when the group in question is in reality no natural group at all, but an "artificial assemblage" composed of several quite unrelated phyla. The primary subdivision of the *Ascidiacea* into these three

sub-orders will therefore not be adopted in my Report; the various genera will be grouped into families upon morphological grounds pure and simple, and will be taken as far as possible in the order of their affinity. From the nature of the case it is impossible to do this with perfect satisfaction, because the families of Tunicates, as of other orders of animals, do not form a single series; but upon completing the description of the species I will present a scheme of classification in which the various families will be bound together according to their most probable phylogenetic relationships.

I desire here to express my warm thanks to Professor Herdman for the assistance which he has liberally given me from time to time; as regards the present paper, I am particularly indebted to him for his kindness in rendering me various information concerning still unpublished work of his upon members of the *Clavelinidæ* and upon Tunicate classification* generally. I am equally indebted to Professor Milnes Marshall for the excellent facilities and help which he has afforded me in his Laboratories.

Order ASCIDIACEA.

Family 1.—CLAVELINIDÆ.

Body consisting of a thorax and abdomen connected by a slender, more or less elongate, œsophageal region. Stolonial tubes arising from the posterior end of the abdomen, rarely from its lateral walls.

Test gelatinous or cartilaginous; forming either distinct sheaths round the stolonial tubes or a common mass investing them; common test never extending above the abdominal region; apertures circular, not lobed, placed near together, terminal.

Musculature consisting almost exclusively of longitudinal bundles; transverse muscles rare.

Branchial sac not folded; horizontal membranes well developed, without papillæ or internal longitudinal bars; dorsal lamina consisting of a series of languettes flattened antero-posteriorly and continuous with the horizontal membranes; stigmata straight.

Tentacles simple, filiform.

Genitalia in the loop of the intestine; oviduct and vas deferens present.

Reproduction by gemmation as well as from ova.

The family, as thus defined, includes the genera *Clavelina*

* Professor Herdman's views upon the classification of the Tunicata will form the subject of a comprehensive memoir in the Transactions of the Linnæan Society, to which Society they were recently communicated.

(Savigny), *Podoclavella* (Herdman), *Stereoclavella* (Herdman), and a new genus, *Pycnoclavella*, described below.

I believe there is abundant reason for dividing the family Clavelinidæ, as regarded by Herdman, into several groups; *Perophora*, indeed, was excluded by Giard in 1872 and by von Drasche in 1883, while still more recently Lahille (1890) has emphasised the differences between *Clavelina* and *Perophora* by placing the former genus in the Distomidæ and the latter in the Ascidiidæ. Von Drasche's family Clavelinidæ includes *Diazona*, but although a near relationship between *Clavelina* and *Diazona* is generally admitted, it must be remembered that the new forms discovered in recent years have rather emphasised than reduced the gap between the two genera; I have therefore excluded *Diazona* from the Clavelinidæ altogether. As above defined, this family includes a number of forms about whose close mutual affinity there can be no doubt.

1. Clavelina, *Savigny*.

Ascidia, *O. F. Müller*. Zoologia Danica, vol. ii, 1788. In part.

— *Bruguière*. Hist. Nat. des Vers, Encycl. Méthodique, Paris, 1792, p. 141. In part.

— *Turton*. Linné's General System of Nature, London, 1802, vol. iv, p. 92. In part.

Clavelina, *Savigny*. Mémoires sur les Animaux sans Vertèbres, Paris, 1816, IIe Partie, pp. 87 and 109. In part.

— *Savigny*. Tableau systématique des Ascidies, p. 171. In part.

— *Fleming*. Molluscous Animals, Edinburgh, 1837, p. 202. In part.

— *M. Edwards*. Observations sur les Ascidies des Côtes de la Manche Mém. de l'Acad. des Sci., Paris, xviii, 1842, p. 50. In part.

Clavellina, *Alder*. Cat. Moll. of Northumberland and Durham, Trans. Tyneside Nat. Field Club, 1848, p. 108.

Clavelina, *Forbes and Hanley*. Hist. Brit. Moll., i, 1853, p. 26.

Clavellina, *Adams*. Genera of Recent Mollusca, London, 1858, vol. ii, p. 595. In part.

Clavelina, *Giard*. Recherches sur les Synascidies, Arch. Zool. Exp., i, 1872, p. 613.

— *Herdman*. Prelim. Report on Tunicata of "Challenger," Proc. Roy. Soc. Edin., x, 1880, p. 717. In part.

— *Herdman*. Rep. on Tunicata, "Challenger" Reports, vol. vi, pt. xvii, p. 245. In part.

— *R. von Drasche*. Die Synascidien der Bucht von Rovigno, Wien, 1883, p. 8.

— *Carus*. Prodromus Faun. Mediterr., Stuttgart, 1890, vol. ii, pt. ii, p. 476.

— *Herdman*. On the Genus Ecteinascidia and its Relations, with Descriptions of two new Species, and a Classification of the Family Clavelinidæ, Trans. Biol. Soc. Liverpool, vol. v, 1890, pp. 160, 161.

Body oblong, more or less clavate, not provided with a post-abdominal peduncle.

Stolons distinct, delicate and branched.

Professor Herdman has quite recently* subdivided this genus as it was defined in his "Challenger" Report. The difference recognised by Savigny between the types *borealis* and *lepadiformis*, in regard to the presence or absence of a well-developed post-abdominal peduncle of test-substance, is raised by him into a criterion of generic value (*Podoclavella*), while the rudimentary "common test" enclosing the stolons of the "Challenger" species constitutes the salient character of his new genus *Stereoclavella*. These changes have been rendered desirable by an increase in the number of species and the apparent† distinctness of the three types. As the table in Professor Herdman's paper shows, the restricted genus now includes the species *lepadiformis* (O. F. Müller), *rissoana* (M. Edwards; variety only ?), *pumilio* (M. Edw.), *producta* (M. Edw.), *Savigniana* (M. Edw.), and *nana* (Lahille).

Is not Müller's *Ascidia gelatina* (Zool. Dan., iv, 26, plate 143) also probably a species of *Clavelina*?

1. Clavelina lepadiformis, *O. F. Müller*. (Pl. II, fig. 1.)

Ascidia lepadiformis, *O. F. Müller*. L. c., p. 54, pl. lxxix, fig. 5.
— — *Bruguière*. L. c., pp. 142, 151, 152; pl. lxiii, fig. 10.
— — *Turton*. L. c., p. 95.
Clavelina lepadiformis, *Savigny*. Tableau systématique, p. 174.
— — *Fleming*. L. c., p. 202, pl. xvi, fig. 57.
— — *Milne-Edwards*. L. c., p. 267, pl. i, fig. i; ii, fig. 1.
— rissoana, *Milne-Edwards*. L. c., p. 267.
— lepadiformis, *Thompson*. Rep. on Fauna of Ireland, Rep. Brit. Ass., 1843, p. 264,
Clavellina — *Alder*. L. c., p. 108.
Clavelina — *Forbes and Hanley*. L. c., p. 26, pl. E, fig. 1.
— — *Dickie*. Rep. on the Mar. Zoology of Strangford Lough, Brit. Ass. Rep., 1857, pp. 105, 111.
— — *Mennell*. Rep. of Dredging Expedition to Dogger Bank and Coasts of Northumberland, Trans. Tyneside Nat. Field Club, 1862, p. 12.
— — *A. M. Norman*. Last Rep. on Dredging among Shetland Isles, Rep. Brit. Assoc., 1868, p. 303.
— — *Giard*. Recherches, l. c., pp. 613—615, pl. xxi, figs. 2, 5; xxiii, fig. 2.

* *On the Genus Ecteinascidia*, &c., loc. cit.

† One of the individuals in Milne-Edwards' figure of *Clavelina producta* (l. c., pl. ii, fig. 3) exhibits a post-abdominal peduncle of some extent.

CLAVELINA LEPADIFORMIS, *McIntosh.* Marine Invertebrates and Fishes of St. Andrews, 1875, p. 54.
— — *Herdman.* Fauna of Liverpool Bay, vol. i, 1886, p. 296, and Proc. Biol. Soc. Liverpool, vol. iii, 1889, p. 245.
— — *Carus.* L. c., p. 476.

Colonies compact, zooids numerous.

Zooids more or less stout, moderately clavate, slightly compressed from side to side, without well-marked external differentiation into thoracic and post-thoracic regions ; average height from a half to three-quarters of an inch.

Test gelatinous, perfectly hyaline and transparent.

Thorax one third of the total body-length ; œsophageal region short ; conspicuous opaque bands of a yellow, brown, or white colour mark the position of the dorsal, ventral and anterior peribranchial sinuses.

Branchial sac with about thirteen transverse rows of stigmata ; horizontal membranes broad.

Habits.—Attached to rocks and stones (rarely to algæ and the backs of crabs, Müller) at the bottom of the tidal zone ; seldom extending into 10 fathoms water.

At Plymouth fine colonies of this species have been found at extreme low water on the north side of Drake's Island, near the "Bridge" under Mount Edgcumbe Park, in tide-pools among the Renny Rocks, and in a few other localities. A few isolated zooids have also been dredged occasionally in 4 to 5 fathoms water near the Duke Rock, and, very rarely, in 10 to 15 fathoms off the Mewstone and Penlee.

On Pl. II, fig. 1, I have represented part of the series of languettes which extends along the dorsal median line of the branchial sac, in order to display their method of connection with the horizontal membranes. The languettes themselves are comparatively narrow and slender ; they are compressed antero-posteriorly and are not connected with one another by any trace of a longitudinal lamina.

The horizontal (interserial or transverse) membranes are thin but well-developed, and may project sufficiently for each one to completely cover the row of stigmata immediately behind it. The free margins of these membranes are perfectly even ; they are not in the least degree scalloped (festooned), and they show no trace of marginal papillæ.

2. Pycnoclavella, *gen. nov.*

Der.—πυκνος, closely united.

External appearance.—Zooids small and delicate, clavate, arising by slender stalks from a more or less thick, basilar mass of test-substance.

Body consisting of a small thorax, a slender, often greatly elongate œsophageal region, and a more dilated abdomen, the greater part of which is imbedded in the basilar mass of common test.

Test thin and delicate around the thorax, thicker and firm in the foot-stalks, dense and cartilaginous throughout the basilar mass; the latter is traversed in all directions by stolonial tubes, some of which even extend and branch in the œsophageal region of the zooids, where they remain sterile or, more rarely, give rise to new buds.

The partial imbedding of the posterior ends of the zooids in a basal mass of test is a character which is common to this genus and the genus *Stereoclavella*, as recently defined by Herdman (l. c., pp. 160, 161); but although this is the only character by which *Stereoclavella* has been as yet distinguished, a comparison of *Pycnoclavella aurilucens* with the described species of *Stereoclavella* shows that marked differences exist between the two genera. In *Pycnoclavella* the zooids arise by slender stalks from the common basal test, and there is a definite demarcation between the two regions; while in *Stereoclavella** it is almost impossible to speak of the common test as a distinct structure. The elegant and regularly clavate form of the free portions of the zooids, together with their delicacy and small size, are also points clearly separating the former genus from the species of *Stereoclavella*. It appears to me to be very probable that the chief character common to these two genera has been attained independently in each case, *Stereoclavella* having arisen from a species of *Clavelina* resembling *C. lepadiformis* in form and size, while *Pycnoclavella* is more akin to *C. producta*.

2. Pycnoclavella aurilucens, *sp. nov.* (Pl. II, figs. 2 and 3.)

Colonies very variable in shape and size, as regards both the thickness and extent of the common test and the length of the free portions of the zooids.

Zooids with thorax slightly compressed from side to side, almost as broad as long, connected with the basal test by a slender cylin-

* The preliminary description given by Professor Herdman of *S. australis* has no reference to the exact character of its common test.

drical foot-stalk of varying length; thorax $\frac{1}{20}$ inch in length; foot-stalk from twice to ten times as long. Abdomen elongate, deeply embedded in the common basal test.

Colour.—A band of golden-yellow pigment extends along the ventral side of the thorax and is continued into the œsophageal region; it is absent from the dorsal side; this band gives a conspicuous colouration to the zooids, when seen alive with the naked eye.

Test of a pale green colour, semi-transparent; thin around the thorax, thicker and firm in the œsophageal region, cartilaginous in the basilar mass; traversed by stolonial tubes in the basal, abdominal, and even œsophageal regions; in the latter region (that of the foot-stalk) the tubes are generally sterile.

Apertures circular, proximate, in the median sagittal plane; branchial terminal, cloacal subterminal.

Branchial sac with seven to nine rows of stigmata; horizontal membranes well developed, broad; dorsal languettes borne on the horizontal membranes, long and stout; endostyle of great size; aperture of hypoganglionic gland simple, circular.

Cardiac structures (pericardium, epicardium) as in *Clavelina;* pericardium not recurved.

Habits.—Irregularly attached along with masses of Polyzoa (*Bugula, Scrupocellaria,* &c.), calcareous sponges (*Leucosolenia*), and compound Ascidians (*Botryllus, Didemnum*) to varied objects from rough ground in 10—20 fathoms water (*e. g.* cases of tubicolous Annelids, *Gorgonia* stems, shelly débris); rarely forming a thin carpet on the stems of red weeds, such as *Delesseria.*

I first noticed this beautiful little Tunicate in the winter and early spring of 1889, when it was dredged several times on rough ground off the Mewstone, on one occasion to the west of it, but generally from half to two miles south or south-west of the rock. This is certainly the best locality for the species at Plymouth, although curiously enough the first specimen was dredged on January 26th in shallower water inside the Breakwater, north-west of the chequered buoy. This first colony was attached to the stem of a *Delesseria,* and formed a thin crust over its surface, the zooids having very short stalks (see Pl. II, fig. 3); the colony was unusually free from adventitious foreign bodies, and the configuration of its parts, especially of the basal test, was much more obvious than in specimens dredged off the Mewstone. These latter colonies are almost inextricably bound up with Polyzoa, Botryllids, Sponges, and other organisms, forming tangled masses in which usually only the brightly gleaming heads of the zooids are visible, the basal test being hidden beneath numerous other organisms and foreign bodies. It is a very

interesting fact that the stalks of the zooids are elongated in direct proportion to the abundance and height of the foreign organisms competing with them for space and oxygen, resembling in this respect numerous epiphytes and other vegetable growths in a thick Brazilian forest.

If the smaller zooids of a living colony be touched with a needle, the bright yellow thorax frequently withdraws itself completely from the greenish test of that region and disappears within the stalks or below the level of the corm. The larger zooids contract upon irritation, but do not completely withdraw in this way. On contraction they give, as it were, a stoop or bend towards the dorsal side—away from the side with the line of yellow pigment; this is due to the fact that the longitudinal muscle-bundles are somewhat more numerous in the dorsal than in the ventral section of the body. Very rarely, if the irritation be continued, the larger zooids may also behave like the smaller ones.

Since I made these experiments with *Pycnoclavella* I have found that Forbes and Goodsir* noticed a precisely similar reaction in the case of their *Syntethys hebridicus.* Indeed, there are several interesting resemblances between the genera *Diazona* (*Syntethys*) and *Pycnoclavella,* the chief of which I may mention as being the greenish colour of the test and the embedding of the abdominal regions of the zooids in a thick basal mass of common test, the thoracic portions remaining free; in *Diazona* this process is more complete than in *Pycnoclavella.*

With regard to the relations of this species to *Clavelina,* I have stated above that although there can be no doubt that both *Stereoclavella* and *Pycnoclavella* are closely allied to that genus, and, indeed, almost certainly derived from it, I believe others will agree with me that this species is more closely related to *Clavelina* itself than to the species of *Stereoclavella ;* its nearest ally seems to be Milne-Edwards' species *Clavelina producta.*† This species produces buds from the lateral walls of the abdomen as well as from the basal stolonial tubes, a fact hitherto without parallel in the Clavelinidæ. *Pycnoclavella aurilucens,* however, exhibits occasionally the same phenomenon (see Pl. II, fig. 2), and there can be little doubt that the stolonial tubes traversing the foot-stalks in this species, whether they remain sterile or produce buds, are the direct homologues of the fertile stolonial tubes of the abdominal walls in *Clavelina producta.* The only other "social Ascidian" possessing morphologically similar structures is *Sluiteria rubricollis* (Van Beneden‡

* Trans. Roy. Soc. Edin., xx, 1853, p. 308.

† Milne-Edwards' Observations, l. c., p. 267, pl. ii, fig. 3.

‡ E. van Beneden, *Les genres Ecteinascidia, Rhopalæa et Sluiteria ; note pour servir à*

and Sluiter), whose transparent test is traversed by several sterile stolonial tubes, branching dichotomously and terminating in a few delicate papillary prolongations on its surface.

These three species illustrate the probable manner in which the "vessels of the test" in Ascidiidæ arose phylogenetically; at first few, short and completely fertile (*e. g. Clavelina producta*), they subsequently increased somewhat in number and extent, dividing dichotomously in the thickness of the test, and became less fertile (*e. g. Pycnoclavella aurilucens*); at a still later stage (represented by *Sluiteria rubricollis*) the tubes became completely sterile, and, though still not numerous, were essentially organs of the test. The loss of the power of blastogenesis altogether would now bring us to the stage occupied to-day by the species of *Ciona;* while an increase in the number of the vessels would lead to the condition found in the greater number of simple Ascidians.

It is interesting to note also that these forms furnish confirmatory evidence of the view enunciated by Della Valle* that the sterile ectodermic tubes of the test have essentially a "palliogenic" function. In *Pycnoclavella aurilucens* the part of the test traversed by them is much thicker and firmer than the thoracic portion, and in *Sluiteria rubricollis* the test is, according to Van Beneden, thicker and more resistant than in *Ecteinascidia*. The test of "social Ascidians" generally is characteristically thin and soft, and this can be referred directly to the absence or very slight development of sterile "palliogenic" tubes. The softness and delicacy of the test of *Ciona* as compared with that of *Ascidia* is also a further confirmation of Della Valle's view.

A fully illustrated account of the anatomy of *Pycnoclavella* will appear in another journal later in the year, and with it will be published coloured sketches of the living colony.

Family 2.—PEROPHORIDÆ.

Body undivided into thorax and abdomen; viscera on the left side of the branchial sac.

Test transparent, for the most part thin and membranous, rarely traversed by a few sterile stolonial tubes; never investing the stolons in a common basal sheath; apertures generally well apart, the branchial terminal and the cloacal dorsal, lobed, or rarely proximate, terminal and only indistinctly lobed.

la classification des Tuniciers, Bull. Acad. Roy. des Sci., &c., Bruxelles (iii), xiv, 1887, pp. 43, 44.

* See Arch. Zool. Exp., x, 1882, *Notes et Revue*, p. xli.

Musculature consisting almost exclusively of transverse fibres; longitudinal fibres rarely present except around the apertures.

Branchial sac not folded, horizontal membranes absent or feebly developed, replaced or surmounted by interserial rows of papillæ; papillæ simple and unbranched or supporting incomplete or complete internal longitudinal bars; bars papillate or not papillate; dorsal lamina a longitudinal membrane or represented by a series of slender languettes; languettes rarely compressed from before backwards; stigmata straight.

Tentacles simple, filiform.

Genitalia in the loop of the intestine; oviduct and vas deferens present.

Reproduction by gemmation as well as from ova.

This family includes the genera *Perophora* (Wiegmann), *Perophoropsis* (Lahille), *Sluiteria* (E. van Beneden), and *Ecteinascidia* (Herdman, sens. strict.). In a complete system of classification it should be placed very near to Roule's group "Phallusidées," which embraces the genera *Ascidiella*, *Ascidia*, and *Phallusia*.

A species of *Ecteinascidia* (*E. Moorei*), quite recently described by Herdman, appears from his figures to possess dorsal languettes flattened antero-posteriorly, and this is implied, though not directly stated, in the text of his paper. This condition of the languettes is unique within the family, and affords an approach towards the genera *Rhopalopsis*, *Rhopalæa*, &c.

3. PEROPHORA, *Wiegmann*.

ASCIDIA, *Lister*. Some Observations on the Structure and Functions of Tubular and Cellular Polypi and of Ascidiæ, Phil. Trans., pt. ii, 1834, pp. 378—382.
PEROPHORA, *Wiegmann*. Jahresbericht, Archives, 1835, p. 309.
ASCIDIA, *Fleming*. Molluscous Animals, Edin., 1837, p. 202.
PEROPHORA, *Forbes and Hanley*. Brit. Moll., 1853, p. 28.
— *Adams*. Genera of Mollusca, 1858, ii, p. 596.
— *Giard*. Recherches, l. c., p. 615.
— *R. von Drasche*. Die Synascidien, 1883, p. 8.
— *Herdman*. Tunicata, Encycl. Brit., 9th edit.
— *Carus*. Prodr. Faun. Med., 1890, ii, pt. ii, p. 476.
— *Herdman*. On the Genus Ecteinascidia, l. c., p. 161.

Zooids quadrangular or oblong, rarely pyriform, never cylindrical, generally compressed from side to side.

Test thin, membranous, without sterile stolonial tubes; apertures apart.

Branchial sac rarely provided with rudimentary horizontal membranes; interserial papillæ triangular or tubular; papillæ simple or

each provided near its extremity with an anterior and posterior longitudinal process; processes rarely fusing to form complete internal longitudinal bars; dorsal lamina, a rudimentary or well-developed longitudinal membrane, supporting interserial languettes compressed from side to side.

Stigmata usually in four, rarely six, transverse rows.

Stolons delicate, distinct, creeping; branches generally alternate in position.

The species included within this genus are at present four in number —*Listeri* (Wiegmann), *Hutchinsoni* (Macdonald), *viridis* (Verrill), and *banyulensis* (Lahille). Of these, *P. banyulensis* may prove not to be distinct from *P. viridis*, as Herdman believes, while *P. Hutchinsoni*, despite Macdonald's careful description and figures, will probably be found on re-examination to present some structural characters not included in the above generic diagnosis.

In his recent paper on *Ecteinascidia* and its allies, Professor Herdman has anticipated me in a description of the interesting condition of the interserial papillæ in *P. viridis*. I can quite confirm his account by my observations on a number of specimens of a *Perophora* which Professor Weldon collected in the Bahamas and gave into my hands some time ago for description. Professor Herdman rightly interprets the bifid or trifid papillæ of *P. viridis* as "rudimentary or imperfect internal longitudinal bars," but so far, I believe, no perfect bars have been discerned in the branchial sac of *Perophora*. In some specimens, however, sent to me from the Zoological Station at Naples, and labelled "Perophora Listeri" I discovered some months ago that numerous perfect internal longitudinal bars actually existed, being supported upon the ends of flat triangular "connecting ducts" precisely as in *Rhopalopsis crassa* or *Ecteinascidia Moorei*, with this difference only, that small papillæ were frequently present at the points of junction. The existence of papillæ on the bars renders the affinity between *Perophora* and *Sluiteria* still closer than has been already believed. It is very probable that a new species must be created for the Naples type, but that is a matter to which I hope to refer in a subsequent paper on the anatomy and variation of the genus. (See *Postscript*, p. 64.)

3. PEROPHORA LISTERI, *Wiegmann*. (Pl. II, figs. 4, 5, 6.)

ASCIDIA, sp., *Lister*. Phil. Trans., 1834, pp. 378—382, pl. xi.
PEROPHORA LISTERI, *Wiegmann*. Archives, 1835, p. 309.
ASCIDIA, n. sp., *Fleming*. Moll. Anim., 1837, pp. 202—209, pl. xvii, fig. 59 (2).
PEROPHORA LISTERI, *Forbes and Hanley*. L. c., p. 28, pl. E, fig. 2.
— — *Giard*. Recherches, l. c., pp. 615, 616, pl. xxi, figs. 3, 6 to 11, 13 to 15, pl. xxiv.

PEROPHORA LISTERI, *Herdman*. Second Report, Proc. Biol. Soc. Liverpool, iii, 1889, p. 246.
— — *Herdman*. On the Genus Ecteinascidia, l. c., pp. 158—161.

Zooids quadrangular, compressed from side to side, colourless, transparent.

Apertures widely separated, branchial with six lobes, cloacal with five.

Tentacles forty in number, of three sizes.

Branchial sac always provided with unbranched digitiform or slightly triangular interserial papillæ; no rudiments of internal longitudinal bars; rudimentary horizontal membranes; stigmata in four transverse rows, two between each pair of interserial papillæ.

Musculature feebly developed; transverse fibres few, widely separate from one another, extending from the dorsal region to the middle of each side; also forming a weak sphincter round each aperture; longitudinal fibres almost as well developed as the transverse, extending from the oral sphincter as far as the level of the first interserial bar of the branchial sac; several longitudinal fibres arising anteriorly between the oral aperture and the anterior end of the endostyle, extending with the longitudinal fibres of the oral sphincter to the same distance; longitudinal fibres of the cloacal sphincter short.

Habits.—Attached to stones or algæ in shallow water.

At Plymouth *Perophora Listeri* has been dredged in the estuary of the Yealm, and in 4 to 5 fathoms water off the Duke Rock. Mr. Heape recorded it as abundant on the rocks below the Hoe.

There can be very little doubt that the name given by Wiegmann to Lister's *Perophora* has been also applied to forms specifically distinct from it. Lister, in his admirable paper, remarks upon the existence of "finger-like processes, about eight in a row, that project nearly at right angles into the central cavity" [of the branchial sac], and these are shown in some of his figures.

Giard also mentions these papillæ and compares them with the papillæ which were figured by Savigny in his account of *Diazona violacea*. These papillæ are simple and digitiform, so that Giard's species probably did not differ from Lister's with respect to these structures.

On the other hand the species found at Naples and, as I gather from Professor Herdman's paper, at Banyuls also (by Lahille) present considerable differences from this simple arrangement. It is probable, therefore, that *Perophora Listeri* does not occur in the Mediterranean but is confined to the Atlantic shores of northern Europe.

The condition of the papillæ in Plymouth specimens is shown on

Plate II, fig. 6, in a drawing taken from preserved material. These structures are seen to have a flattened triangular shape and are connected at their bases by very low and rudimentary horizontal membranes (cf. fig. 7). In life, these papillæ assume a more extended digitiform shape, as Lister long ago stated. If these papillæ were to be connected by internal longitudinal bars (as frequently occurs in the Naples species), meshes would be formed, each containing two stigmata.

The opening of the duct of the hypoganglionic gland (fig. 7, *c. v.*) is simply circular. It is situated in front of a raised triangular area, whose apex is posterior; this constitutes what is undoubtedly the homologue of the epipharyngeal groove. A precisely similar structure has been figured by Roule for *Rhopalæa nepolitana*,* and observed in *Sluiteria rubricollis* by E. van Beneden.† From the posterior apex of this area arises the dorsal lamina (fig. 7, *d. l.*) as a low membrane which increases slightly in height as it extends posteriorly. At the level of each horizontal membrane it rises up into a curved triangular languette (*l*), and occasionally there is a small projection from its edge between each pair of interserial languettes (fig. 8, *i. p.*). An examination of fig. 7 also shows that the horizontal membranes really are continued upon the lateral faces of the dorsal lamina, although they do not extend along the languettes.

The structure of the dorsal lamina in this species approaches closely in essential features that described by van Beneden in *Sluiteria rubricollis*, in which form there is a continuous longitudinal membrane whose border is cut into festoons in correspondence with the number of transverse (interserial) bars. The lamina is provided with fourteen oblique ridges which also correspond in number with the horizontal bars. Although in his diagnosis of the genus *Sluiteria*, Professor van Beneden denies the presence of horizontal membranes (*l. c.*, p. 43), he admits in his description of *S. rubricollis* that the connecting ducts of the internal longitudinal bars "spring by an enlarged base from little interserial folds traversing the length of the transverse bars" (p. 34). This is precisely the condition I have found in the Naples *Perophora*, and it is essentially similar to what is here described for *P. Listeri*; interserial membranes are in each case present, but rudimentary. The ridges on the lamina of *S. rubricollis* are therefore undoubtedly of the same nature as the less conspicuous elevations formed in *P. Listeri* by the continuation of the horizontal membranes upon the sides of the lamina (see fig. 7).

* Roule, *Rev. des Esp. de Phallusiadées de Provence*, Rec. Zool. Suisse, iii, pl. xiv, fig. 14.

† Ed. van Beneden, Sur les genres Ecteinascidia, &c., l. c., p. 35.

Further the lamina of *Sluiteria rubricollis* is described as being enrolled, the concavity being to the right; my figure also shows that the marginal languettes of *P. Listeri* are bent over in a precisely similar way.

In *Ecteinascidia turbinata* (Herdman) and *diaphanis* (Sluiter) the dorsal lamina is represented by tentacular languettes unconnected by a longitudinal membrane. This membrane is present in *E. Thurstoni* (Herdman), while horizontal membranes are quite absent, and with them also every trace of interserial ridges on the sides of the dorsal lamina. In *E. Moorei* (Herdman) all the horizontal structures are well developed, but the longitudinal lamina is absent.

Family 3.—DIAZONIDÆ.

Body large, consisting of a thorax and abdomen connected by a slender, more or less elongate œsophageal region; stolonial tubes arising from the posterior end of the abdomen.

Test gelatinous or semi-cartilaginous, greatly developed around the basal stolonial tubes, with formation of a thick common test, in which the abdominal portions or the entire bodies of the zooids are imbedded; apertures terminal, each divided into six lobes, rarely smooth.

Musculature consisting of both longitudinal and transverse fibres, which for the most part anastomose freely; longitudinal fibres especially well developed.

Branchial sac large; with or without festooned horizontal membranes; interserial papillæ always present, supporting complete or rudimentary internal longitudinal bars; longitudinal bars not papillate; dorsal lamina represented by a series of languettes with long tapering ends; dorsal tubercle a large, longitudinally ovate slit surrounded by broad raised margins; branchial sac not folded.

Heart recurved upon itself.*

Genitalia in the loop of the intestine, or extending considerably behind it; oviduct present or absent.

Reproduction by gemmation as well as from ova, with formation of colonies of great size; colonies without systems.

This family, including the genera *Diazona* (Savigny) and *Tylobranchion* (Herdman), has relations both with the Cionidæ, Distomidæ, and Polyclinidæ. To Lahille belongs, I believe, the credit of first emphasizing the resemblances between *Diazona* and *Tylobranchion*, the latter being one of the most interesting of the "Challenger" forms made known to us by Professor Herdman's researches. As

* This has not yet been established for *Tylobranchion*, but is probably the case.

I gather from Professor Herdman's remarks upon Lahille's system of classification, this zoologist groups together, along with *Diazona* and *Tylobranchion*, the genera *Ecteinascidia*, *Rhopalæa*, and *Ciona*. I believe, however, that *Ecteinascidia* is much more closely related to *Sluiteria* than to any of these genera, and while Roule has established the relationship of *Rhopalæa* and *Ciona* beyond doubt, the equally close affinity of *Diazona* to these forms is still a matter of some uncertainty. That the mere formation of a huge common mass of test enclosing the abdominal regions of the zooids is not of itself a point of great systematic importance is demonstrated by *Pycnoclavella*, which is in every other structural respect a true *Clavelina*. Therefore on this head I am quite in accord with Lahille in his efforts to break up the group "Ascidiæ compositæ," and to classify the Ascidians upon morphological grounds only or in the main. Yet I cannot but regard the definite position of *Diazona* and *Tylobranchion* among the Cionidæ as too forcible a disregard of the ties which also bind them to the Polyclinidæ and Distomidæ.

4. Diazona,* *Savigny*.

Diazona, *Savigny*. Tableau systématique, l. c., pp. 174, 175.
— *Dujardin*, in *Lamarck*. Hist. Nat. des Anim. sans Vertèbres, 2nd ed. (par Deshayes and M. Edwards), t. iii, 1840, pp. 498, 499.
Syntethys, *Forbes and Goodsir*. On some Remarkable Marine Invertebrata new to British Seas, Trans. Roy. Soc. Edin., xx, 1853, p. 307.
— *Forbes and Hanley*. Brit. Moll., iv, p. 244.
Diazona, *Alder*. Observations on British Tunicata, Ann. and Mag. of Nat. Hist. (iii), xi, 1863, p. 169.
— *Lahille*. Comptes Rendus, cii, 1886, p. 1574, and civ, 1887, p. 240.
— *Giard*. Comptes Rendus, ciii, 1886, pp. 755, 756.
— *R. von Drasche*. Die Synascidien, p. 8.
— *Carus*. Prodr. Faun. Med., 2, ii, p. 480.

Colony gelatinous, sessile; the zooids superior, their thoracic portions freely projecting.

Musculature with longitudinal fibres united into well marked bundles.

Branchial sac with festooned horizontal membranes, supporting complete, rarely incomplete, internal longitudinal bars, not papillate at the point of junction; dorsal languettes triangular, compressed from before backwards.

Genitalia in the loop of the intestine; oviduct (always ?) and vas deferens present.

* I greatly regret that my efforts to obtain a copy of Della Valle's Contribuzioni have been unsuccessful up to the time of going to press, and I must express the same regret with regard to Lahille's Recherches sur les Tuniciers.

In 1853 Professors Forbes and Goodsir announced the discovery of a composite Tunicate allied to Savigny's *Diazona violacea*, but differing from it in the possession of the following characters: Plain undivided orifices, non-pedunculated abdomen, meshes with "one ciliated opening" only, and apple-green colour. Their genus *Syntethys* was established upon these grounds, but Alder subsequently wrote to show the generic identity of the two forms, basing his criticisms upon an examination of specimens dredged near Guernsey and possibly upon a re-examination of a portion of one of the original specimens of Forbes and Goodsir. Alder satisfactorily showed that the difference of colour was one due entirely to the action of the spirit used in preservation, and also that the pedunculation of the abdomen is very variable in its extent. He also noted that, after preservation, the division of the apertures into lobes was generally difficult to make out. His conclusion in regard to the generic identity of *Diazona violacea* and the so-called *Syntethys* is probably correct, although, as I shall endeavour to show below, his identification of the Guernsey species with that of Forbes and Goodsir from the Hebrides is extremely doubtful.

4. Diazona violacea, *Savigny*. (Pl. II, figs. 7, 8.)

Diazona violacea, *Savigny*. Mémoires, pp. 35—38, 175, 176, pl. xii.
— — *Fleming*. Moll. Animals, 1837, p. 211.
— mediterranea, *Dujardin*. L. c., pp. 499, 500.
— hebridica, *Alder*. L. c., p. 169.
— violacea, *Carus*. L. c., pp. 480, 481.

Colony massive, irregularly rounded, attached by a short, thick pedicle or base; total diameter about 7 inches, total height 5 or 6 inches; of apple-green colour when alive, semi-transparent.

Zooids often 2 inches long, with oral and cloacal orifices each six-rayed.

Branchial sac with sixty to eighty transverse rows of stigmata; meshes each containing three, rarely four stigmata; internal longitudinal bars for the most part completely formed, but here and there represented by T-shaped interserial papillæ, as in *Tylobranchion;* dorsal tubercle a large deep groove, elongate antero-posteriorly, with thickened walls.

Habits.—Attached to rocks or stones in deep water.

Dredged at Plymouth on rough ground off Stoke Point, and off the Eddystone in 20—40 fathoms of water.

There are two remarkable statements in the original description of the structure of *Syntethys Hebridicus* by Forbes and Goodsir

which have not, to my knowledge, received the attention which they deserve. They are involved in the following account given by these naturalists of the branchial sac in their specimens :

"Branchial chamber with thirteen transverse rows of oblong openings, fringed with ciliated epithelium; hooked fleshy tubercles at the intersections of the branchial meshes, each mesh presenting one of the ciliated openings ; the tubercles give the internal surface of the chamber a dotted appearance." (Trans. Roy. Soc. Edin., 1853, p. 307, cf. also Forbes and Hanley, l. c., p. 244.)

Now, in the specimens of *Diazona violacea* dredged at Plymouth, the number of transverse rows of stigmata greatly exceeds that given by the eminent naturalists who described *Syntethys Hebridicus ;* the number is usually about sixty, seventy, or even more! Further, the stigmata in each mesh are invariably three or four, the latter number agreeing with the description and figure given by Savigny.

Were Professors Forbes and Goodsir mistaken? Such a theory is unlikely, for one of their figures (l. c., pl. ix, fig. 4 *d*) shows in outline some of the appearances which they recorded in the words quoted above. Indeed, this figure is too precise to admit of any doubt as regards the approximate number of *transverse* bars (and, therefore, rows of stigmata) in their specimens, and a difference in this respect between *Diazona violacea* and *Syntethys Hebridicus* must, I think, be admitted.

But the more remarkable statement is that "each mesh presents one of the ciliated openings." That Forbes and Goodsir should have made a mistake in the observations which gave rise to this statement seems inconceivable, but it is surprising that they pass no reflection upon so unusual a condition of the branchial sac. There was plainly no error in the identification of the "meshes," for "hooked fleshy tubercles" are stated to be present at the "intersections of the branchial meshes" (a somewhat confused but quite intelligible statement). Still, the fact of one stigma alone being included in each mesh has either to be accepted or explained away.*

It is conceivable that the appearance of one "ciliated opening" corresponding to each mesh was due to a great transparency of the "trame fondamentale" of the branchial sac, and that while the meshes were observed, the true stigmata were not noticed; but I cannot reconcile this hypothesis with the assertion, so definitely made, that the "oblong openings" were "fringed with ciliated epithelium." It is also impossible, and for the same reason, to imagine that the

* This condition exists in *Polyclinum sabulosum* (Lahille, Comptes Rendus, cii, p. 1574), and is approached in *Tylobranchion speciosum*.

meshes were totally devoid of stigmata, as in *Pharyngodictyon mirabile* of the "Challenger" collection, described by Herdman.*

I am obliged, therefore, to conclude that *Syntethys Hebridicus* actually possessed, as Forbes and Goodsir stated it to possess, a branchial sac containing about thirteen transverse rows of oblong stigmata, and presenting a "hooked fleshy tubercle" at the junction of every longitudinal and horizontal bar.

It should be noticed that in the original description there is nothing irreconcilable with the view that the branchial sac of *Syntethys Hebridicus* may in reality have been quite destitute of true internal longitudinal bars, and possibly of horizontal membranes; the "hooked fleshy tubercles" may have been such rudimentary connecting ducts and bars as Herdman has described and figured for *Tylobranchion speciosum* (l. c., p. 161). In this connection I may state that I find the internal longitudinal bars of *Diazona violacea* to be by no means rarely incomplete in portions of the branchial sac; they are then represented by structures which could well be described as "hooked fleshy tubercles."

I will not maintain that this new view of Forbes and Goodsir's very "remarkable invertebrate" is probable, but it is at least possible. If it should prove eventually to be correct, a very interesting connection between *Diazona violacea* and *Tylobranchion speciosum* will have been established.

By admitting the above-named differences between the branchial sacs of *Diazona violacea* and *Syntethys Hebridicus*, it will be noticed that I do not accept Alder's identification of his Guernsey specimens of *Diazona* with Forbes and Goodsir's species. From Alder's account I have been led to believe that he assumed this identity too hastily. He states that his specimens were "at once recognised as the *Syntethys Hebridicus* of Forbes and Goodsir," and upon this assumption he endeavoured to find out what structural differences there might be between this form and the *Diazona violacea* so admirably described by the great French anatomist. His researches were not very fruitful of result: "The only difference I can find is that the papillæ of the branchial sac in the latter (*Syntethys Hebridicus*) are stout and obtuse, very different from the slender pointed form represented by Savigny; I have therefore determined to consider them distinct until further observations decide the point."

Now Alder's Guernsey specimens are certainly identical (specifically) with the forms investigated by myself, and they are both from practically the same region of the English Channel; there is further no appreciable difference between the Plymouth forms and

* Herdman, "Challenger" Report, vol. xiv, pt. xxxviii, p. 155.

Savigny's species. Therefore Alder's examples must also be referred to the species *Diazona violacea.*

The absence of any indication in Alder's paper that he re-examined the "portion of a specimen (of *Syntethys Hebridicus*) from the original habitat" which Professor Goodsir sent to him, renders intelligible what would otherwise have been a very strange omission on his part. I refer to his failure to notice the remarkable discrepancy between the structure of the branchial sac in the Channel specimens and that described for *Syntethys Hebridicus.*

Thus, although I quite agree with Alder that there is as yet no sufficient ground for generically separating these two forms, I believe Forbes and Goodsir's species to be perfectly distinct and to possess the following distinguishing characters:

Orifices not divided into lobes, evenly rounded.

Zooids projecting freely by their thoracic portions, which are united to the common mass by a slightly contracted but not pedunculated œsophageal region.

Branchial sac with thirteen transverse rows of oblong stigmata; a hooked interserial papilla (connecting duct) at the intersection of every longitudinal (interstigmatic) and transverse bar.

Oviduct absent (?)

But the whole matter is so beset with doubts that it is greatly to be desired that specimens should be obtained again from the Hebrides, and their anatomy re-described. Unfortunately Giard gives no anatomical details of the *Diazona* dredged by him and described in Comptes Rendus, ciii, p. 755.

DESCRIPTION OF PLATE II.

Illustrating Mr. W. Garstang's "Report on the Plymouth Tunicata," pt. 1.

N.B.—Where not otherwise stated all the figures were drawn from preserved material.

FIG. 1.—*Clavelina lepadiformis,* O. F. Müller. Three of the dorsal languettes of the branchial sac. Zeiss, A, Oc. 2, Cam.

d.s. = Dorsal sinus.

h.m. = Horizontal membrane.

FIG. 2.—*Pycnoclavella aurilucens,* gen. et sp. nov. Portion of a colony. A section has been taken through the colony in order to show the common test and the imbedded portion of the zooids. Nat. size; slightly diagrammatic.

c.t. = Common test.

t.p. = The free portions (thoracic and œsophageal) of the zooids projecting from the common test.

v.p. = The visceral portions of the zooids imbedded in the common test.

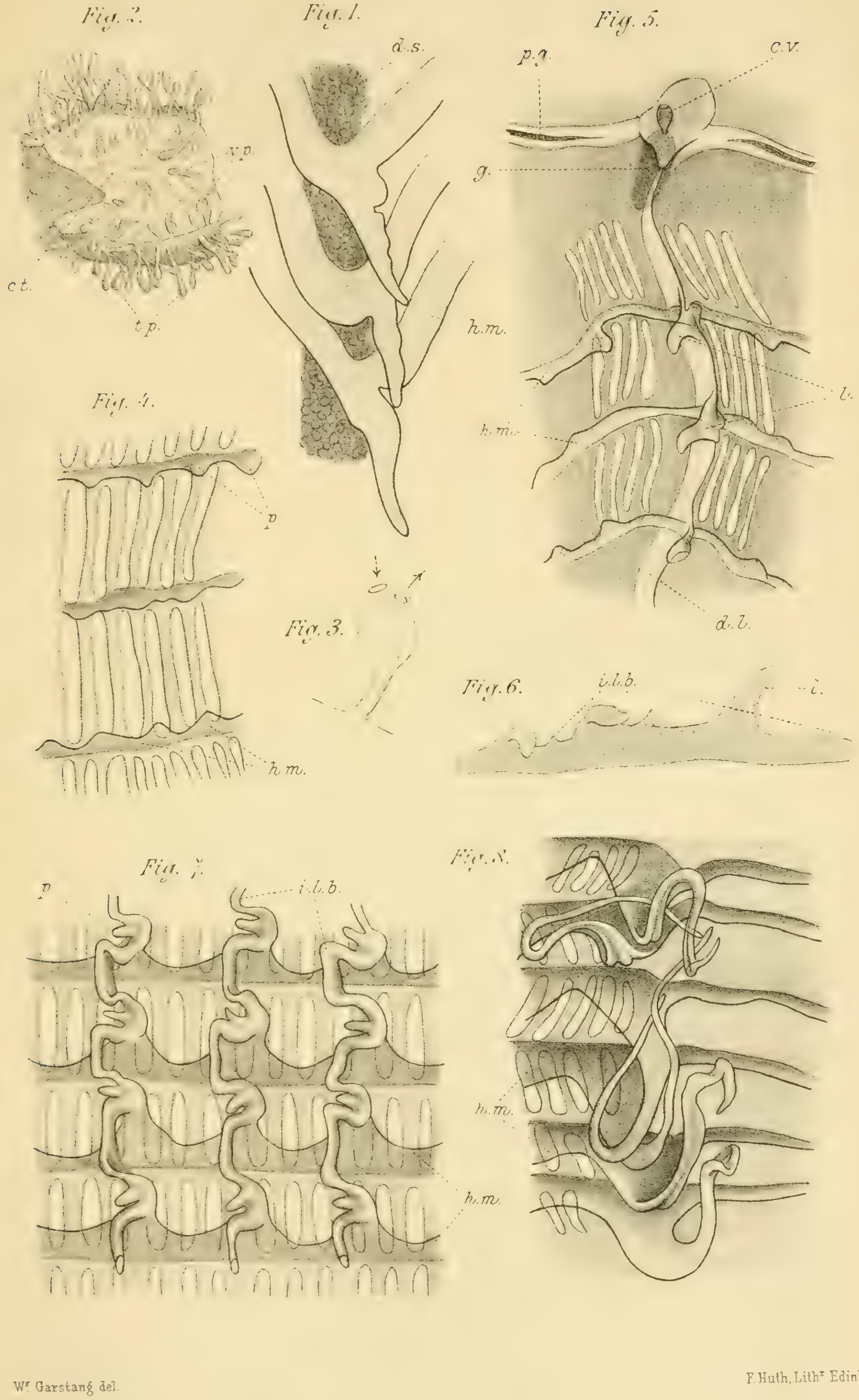

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FIG. 3.—*Pycnoclavella aurilucens,* gen. et sp. nov. The free portion of a zooid from a colony growing on the stem of a *Delesseria.* Drawn from life, enlarged.

FIG. 4.—*Perophora Listeri,* Wiegmann. Portion of the branchial sac. Zeiss, A, Oc. 2, Cam. luc.

h.m. = Rudimentary horizontal membranes.
p. = Interserial papillæ (= rudimentary connecting ducts).

FIG. 5.—*Perophora Listeri,* Wiegmann. Dorsal wall of pharynx, showing dorsal lamina and aperture of hypoganglionic gland, seen from inside. Zeiss, A, Oc. 2, Cam. luc.

p.g. = Pericoronal groove.
c.v. = Ciliated vesicle, opening on the surface of a shield-shaped pad.
g. = Ganglionic mass.
d.l. = Longitudinal membrane of dorsal lamina.
l. = Marginal languettes.
h.m. = Rudimentary horizontal membranes.

FIG. 6.—*Perophora Listeri,* Wiegmann. Dorsal lamina of another individual, seen from the right side. Zeiss, A, Oc. 2, Cam. luc.

l. = Marginal languettes, interserial in position.
i.p. = Small marginal projections intermediate between the languettes.

FIG. 7.—*Diazona violacea,* Savigny. Portion of branchial sac, seen from inside. Magnified, slightly diagrammatic.

h.m. = Horizontal membranes.
i.l.b. = Internal longitudinal bars.
p. = Papillæ of the connecting ducts. (See *Postscript.*)

FIG. 8.—*Diazona violacea,* Savigny. Six dorsal languettes. Zeiss, A, Oc. 2, Cam. luc.
h.m. = Horizontal membranes.

Postscript.—By Professor Herdman's kindness I have recently been enabled to consult Lahille's important *Recherches sur les Tuniciers.* Lahille points out that the appearance of papillæ on the internal longitudinal bars of the branchial sac of *Diazona violacea,* as previously described by Savigny and Della Valle, is a false one, produced by the thickened remains of the "primitive branchial languettes." I had myself, like Alder, failed to find any such vertical papillæ as were represented by Savigny for this species, and was struck by their apparently recumbent position in mounted preparations (see fig. 7); but a re-examination by means of dissecting needles has convinced me that Lahille is quite correct in denying their existence altogether. The necessary correction has been made in the text of my paper, but the diagram given on fig. 7 is in this respect misleading. Lahille also states that the horizontal membranes are very little developed, but this is by no means the case in the Plymouth specimens.

I have stated above (p. 55) that my discovery of internal longitudinal bars in the Naples *Perophora* will probably necessitate the creation of a new species; but from Lahille's description this species would appear to be identical with his *P. banyulensis.* The Naples species differs widely from *P. viridis* as regards its musculature, a fact which thus militates against Professor Herdman's suggestion that *P. banyulensis* is a synonym of *P. viridis.*

W. G.

On some Larval Stages of Fishes.

By

J. T. Cunningham, M.A.,
Naturalist to the Association.

With Plates III and IV.

The six drawings reproduced in Plates III and IV were made at sundry times from stages that I succeeded in obtaining in the years 1889 and 1890. The three stages of the common sole were procured after my quarto book on that fish was completed, and they enable me to supplement the account of the life-history of the species given there.

Fig. 1 represents a larva of *Solea vulgaris* four days after hatching. The drawing reproduced was made from the living larva on April 26th, 1890; the larva was hatched on April 26th from an egg artificially fertilized on April 14th on board a trawler off the north coast of Cornwall. The temperature of the surface water of the sea in which the eggs were fertilized was 9·7° C., of the water in the Laboratory in which the eggs were kept 10·8° C. The variations of temperature in which the eggs were carried while on board the trawling smack were not observed. I can only, therefore, give an approximation to the relation between temperature and the period of development of the egg, namely, that at a mean temperature of about 10·0° C. the eggs of the sole hatch in eight days.

The condition of the larva of the sole immediately after hatching is described and illustrated in my Treatise on the species. The changes which have occurred in the stage represented in fig. 1 are the following: The yolk, *yk*, is much reduced in bulk, about half the quantity present at hatching having been absorbed. Three groups of oil globules are still visible on the surface of the yolk, the individual globules being larger than in the newly hatched larva, doubtless because some coalescence has occurred. In the newly-

hatched larva the intestine is straight, and lies in a depression of the dorsal surface of the yolk, while in the present stage the intestine shows the commencement of a convolution above the yolk, and the latter does not project dorsalwards on each side of the gut. The whole of the anterior part of the body is now straightened out, while at the time of hatching it was bent downwards towards the anterior extremity. Accordingly the region of the fore-brain and olfactory organ is now at the anterior extremity of the axis of the body. The position of the olfactory organ is indicated by *ol.* in the figure, although the organ itself was not distinct enough to be represented in the figure when the drawing was made. The intestine or alimentary tube has now grown forwards beneath the brain to meet the skin beneath the fore-brain and eyes, and the lumen or cavity of the tube, open in the posterior part, is faintly indicated anteriorly by a line; the mouth, however, is not yet open, although the lumen of the gut extends to the exterior at the anus. The heart, *ht.*, has the usual structure in larval fish at this stage; it consists of a tube beneath the gullet having an aperture posteriorly, by which it communicates with the perivitelline sinus. The heart is surrounded by a cavity, which is separated from the perivitelline sinus by a delicate membrane, and which is afterwards extended to form the body-cavity. Pigment has begun to appear in the eye, *i. e.* in the choroid membrane, as separate dots. The mid-brain, *m. b.*, projects dorsally. The primordial membranous fin of the larval sole is characterised by its irregularity of outline anteriorly. The edge of this fin forms a projection over the mid-brain, and another behind the head. The pigmentation of the skin consists of black and yellow dendritic (*i. e.* branched) chromatophores. On the fin these chromatophores form four not very definitely marked spots on the dorsal portion, and one posteriorly on the ventral portion. At later stages these spots become more definite and conspicuous. The total length of the larva represented in fig. 1 was 4·35 mm.

Fig. 2 shows an older larva from the same lot. It was drawn on April 28th, that is, six days after hatching. The mouth is now fully developed, although a remnant of the yolk is still unabsorbed, and the larva has not yet begun to feed. The eye is now completely pigmented, the choroid membrane being black and opaque. The auditory vesicle, in the previous stage a simple spherical capsule with two calcareous nodules inside it, is now much enlarged, and exhibits the commencement of the semicircular canals within it. The olfactory organ, *ol.*, has the form of a spherical capsule just beneath the skin, opening to the exterior by a circular aperture. There is, of course, one of these on each side of the snout; the

division of each aperture into the two nostrils which exist on each side in the adult takes place later. The convolution of the intestine, although still simple, is much larger and more conspicuous in consequence of the increase of the intestine in length. The heart has the same relations as in the previous stage. The pectoral fin is visible as a somewhat quadrangular membranous fold projecting from the side of the body behind and below the auditory organ. The great bluntness of the anterior edge of the head is very characteristic of the larval sole at this stage. The mid-brain is still very prominent dorsally. The dorsal edge of the primordial fin still presents the two rounded projections described in the previous stage. The pigmentation of the skin is now more developed than before. The length of the larva from which fig. 2 was prepared was 4·2 mm., rather less than that of the specimen represented in fig. 1. Fig. 2 represents the appearance of the larva as seen partly by reflection, partly by transmission of the light; the light was partly excluded from the aperture of the stage of the microscope, so that the specimen was seen against a somewhat dark background, as shown in the figure.

The stage shown in fig. 2 is the oldest which I have examined in larvæ reared in confinement from artificially fertilized ova; all the larvæ I reared last year, died soon after this stage was reached. Fig. 3 shows the appearance during life of an older larva which I obtained in Cawsand Bay, Plymouth Sound, on May 14th, 1890. It was captured in a small trawl made of cheese-cloth and worked on a sandy bottom in three to five fathoms of water. I think there can be no doubt that this larva belonged to *Solea vulgaris*. I identify it by the distribution of the pigment in the skin, especially the spots on the dorsal and ventral fin, and by the shape of the head. The tissues of the body, though still translucent, were no longer transparent enough at this stage to show the internal organs so clearly as at the stages previously described. The chief features to notice at this stage are as follows. The notochord is bent upwards at its posterior extremity, and the caudal fin-rays are beginning to appear beneath the bent portion. The lateral muscles of the body are defined dorsally and ventrally by a distinct margin, between which and the base of the median fin-membrane is a region in which the interspinous bones, *is b.*, have begun to appear. The liver, *l.*, is visible as a large mass towards the anterior margin of the abdominal cavity. Behind the intestine, *int.*, is seen the urinary bladder, *u. b.* The prominence of the mid-brain and the projections of the outline of the longitudinal fin over the head have disappeared, but the fin membrane still extends forwards in front of the eyes. The eye has a blue colour, probably due to iridescence of the

choroid membrane. The auditory vesicle is very large, and extends dorsalwards far above the level of the eyes. The pigmentation of the skin is characterised by the development of very definite spots along the sides of the dorsal and ventral fin membrane. In the centres of these spots as well as over the sides of the body there are small orange spots in addition to the yellow and black of the earlier stages. Judging from what I have seen in the skin of the adult plaice and sole, I believe that the orange is not a new pigment, but the same pigment as the yellow in a more concentrated form; in fact I have reason to conclude that there are only two pigments in the skin of flat fishes, the black and the yellow, the latter being yellow when spread out, orange or even red when concentrated into a thicker globule. It will be seen on comparison that my fig. 3 differs very greatly from the figure of a larval sole of about the same size, 5 mm., given by Professor McIntosh in Plate III of the seventh Annual Report of the Scottish Fishery Board. We do not know the whole development of the sole with sufficient completeness to justify a definite assertion on the matter, but I cannot help doubting for the present whether Professor McIntosh's figure represents a stage of the larval sole at all.

In my paper published in this Journal March, 1889, I was unable to describe the larva of the mackerel. In the summer of that year I succeeded in hatching some artificially fertilized ova of the species, but could not keep them alive for any length of time. Pressure of other work has prevented me since from devoting much attention to the mackerel, and all I have to add now is a figure of the newly hatched larva, fig. 4. The drawing reproduced in this figure was made on July 2nd, 1889. The egg, from which the larva hatched, was one of a number artificially fertilized for me by mackerel fishermen on board their own boats. The length of the larva was 4·23 mm. In structure the larva does not differ essentially from other species belonging to the Physoclisti, or Teleosteans with closed air-bladders.

As in most other larvæ of that division, the rectum is immediately behind the short oval anterior yolk-sac. The notochord is as usual multicolumnar, composed of several columns of cells. The mouth is not open, and the eye (choroid membrane) is unpigmented. The slender elongated form of the larva is characteristic. But the chief distinguishing feature is the pigment of the skin and its distribution. The pigment consists of chromatophores of two colours, black and green, as in the adult. There is no pigment at all on the primordial median fin membrane. Black chromatophores occur over the sides of the body and head, especially along the edges of the body. The green chromatophores, mingled with black, occur only

in five spots in the neighbourhood of the yolk-sac. The largest of these is not in the skin, but on the surface of the yolk-mass over the oil-globule, which is situated at the posterior end of the yolk. Another is at the base of the rudiment of the pectoral fin, *pe. f.* Another is just behind the eye, and two others are at the anterior end of the yolk-sac.

The larva represented in fig. 5, Plate IV, is that of *Cottus bubalis*, a species extremely common on the shore at Plymouth. The eggs of this species are adhesive and are deposited in small rounded clumps of about one and a half to two inches in diameter attached to stones or rocks on the shore. There are usually numbers of the fish in our tanks, where they regularly deposit their eggs. The deposition of the eggs takes place in January, February and March. The single egg is 1·7 mm. in diameter, and is characterised by the presence of rounded protuberances all over the external surface of the envelope. The yolk when the egg is first laid has usually several rather large oil-globules, but during development these coalesce into a single globule. Fig. 5 shows the appearance and structure of the living larva immediately after hatching. The larva is in a much more advanced condition than those of species hatched from pelagic eggs. Its length is 5·7 mm. The mouth is open and the cartilaginous branchial arches are already formed. The choroid of the eye is fully pigmented, and has a deep blue colour by reflection. Some of the yolk still remains and the oil-globule is situated at its anterior surface. The condition of the heart is quite different from that seen in newly hatched pelagic larvæ; instead of a continuous perivitelline blood sinus, there are numerous definite vitelline vessels, *v. v.*, and in these, circulates fully developed red blood, containing numerous red corpuscles. These vitelline vessels lead to the posterior end of the heart, and in the opposite direction are seen to be continuous with the vessels of the liver *l.* On the dorsal side of the liver, in the figure, is seen the gall-bladder, conspicuous from the green colour of its contents. Above the liver is seen the enlargement of the intestinal tube forming the stomach, but the tube is without convolutions. The notochord is multicolumnar, and below it are seen the caudal artery and vein, *c. v.*, in which the blood is seen in the living larva coursing in opposite directions. The pectoral fin, *pe. f.*, is large and membranous, with a semicircular outline. The auditory vesicle with its two calcareous nodules, and developing semicircular canals, is a conspicuous structure behind the eye. The distribution of pigment in the larva is peculiar. Black pigment only is present, yellow not being developed till a later stage. Pigment is altogether absent from the caudal region; the black chromatophores are almost en-

tirely confined to the dorsal region of the peritoneum, where they are closely aggregated in a saddle-shaped area over the region of the stomach and rectum. There are also a few chromatophores in the skin behind the base of the pectoral fin. Professors McIntosh and Prince* give a figure of a later stage identified by them as belonging to *Cottus scorpius ;* the latter species is abundant on the Scottish coast, but I have not yet met with it at Plymouth. Their figure shows little detail, and they do not note the fact that the characteristic saddle of black pigment is situated in the peritoneum and not in the skin. In the larva figured by them yellow pigment is present on the head and abdominal region.

Fig. 6, Plate IV, represents an advanced larval stage identified as belonging to the grey mullet *Mugil chelo.* The little fish was taken in Mevagissey Harbour and sent to our Laboratory alive by Mr. Matthias Dunn, on May 10th, 1890. I have identified it by the shape of its head and snout, and by comparison with more advanced young of the same species which occur abundantly near Plymouth in summer. It was 10·5 mm. in length. The yolk is entirely absorbed, and the body opaque and pigmented. But the fins still retain their larval membranous character, the formation of the fin-rays having only commenced in the caudal region beneath the upturned extremity of the notochord. The air-bladder, *a. b.*, is conspicuous; the pectoral fins are large. The pigmentation of the skin is a general yellow ground with numerous black chromatophores scattered over it; the yellow colour would, of course, also be resolved into chromatophores under a higher magnifying power.

Raffaele in his paper in the *Mittheilungen* of the Zoological Station at Naples, vol. viii, gives figures of the ovum, and the newly-hatched larva of a species of *Mugil* or mullet. The ovum is pelagic and small, it has a single large oil-globule. There is little that is characteristic in the figure of the newly-hatched larva, except that the yolk is ellipsoidal instead of spherical, and the pigment is yellow and black as in the stage I have above described.

* *Development of Teleostean Fishes,* Trans. Roy. Soc., Edinb., vol. xxxv, pt. iii, 1890.

DESCRIPTION OF PLATES III AND IV,

Illustrating Mr. Cunningham's paper "On Some Larval Stages of Fishes."

Reference Letters.

a. b. Air bladder. *au.* Auditory organ. *c. v.* Caudal blood-vessels. *ht.* Heart. *int.* Intestine. *is. b.* Interspinous bones. *l.* Liver. *m. b.* Mid-brain. *pe. f.* Pectoral fin. *u. b.* Urinary bladder. *v. v.* Vitelline blood-vessels. *yk.* Yolk.

PLATE III.

FIG. 1.—Larva of *Solea vulgaris,* from egg artificially fertilized. Hatched April 22nd, drawn April 26th, 1890. Zeiss, a_3, oc. 3, camera.

FIG. 2.—Larva of *Solea vulgaris,* hatched same date, drawn April 28th. Zeiss, a_3, oc. 3, camera.

FIG. 3.—Larva of *Solea vulgaris,* caught in Cawsand Bay, May 14th, 1890.

PLATE IV.

FIG. 4.—Larva of *Scomber scomber* (mackerel), newly hatched. Zeiss, a_3, oc. 3, camera.

FIG. 5.—*Cottus bubalis,* newly hatched. Zeiss, a_3, oc. 3, camera.

FIG. 6. Larva of *Mugil chelo* (grey mullet). Zeiss, a_3, oc. 2, camera.

Plate III.

J. T. Cunningham del.

F. Huth, Lith.r Edin.r

Plate IV.

J. T. Cunningham del.

F. Huth, Lithr. Edinr.

NOTES AND MEMORANDA.

1. **Hermit Crabs and Anemones, &c.**—It is often so difficult to make systematic observations on the inter-relations of animals, that a bare record of the merest fact may prove eventually to be of use. These few lines, on one or two small occurrences in the aquarium and elsewhere, are printed here, not from any intrinsic interest, but in the hope that they may be useful to some future worker.

Upon the relations existing between certain Actinians and Crustacea, observations are much needed. In a tank containing several *Pagurus Bernhardus* and *Adamsia Rondeletii* (*Sagartia parasitica*), which are habitually associated in a form of commensalism, most of the Paguri for one reason and another died, and their anemones in some cases crawled off the shell and throve independently (this has been noticed also in the case of *Adamsia palliata*). One of three specimens of *Maia squinado* living in the same tank, presently appeared bearing first one, then two, finally three *Adamsia Rondeletii* on its walking legs ; one, if I remember right, was placed on the first walking leg of each side, the third on the second leg of the right side. The limbus of the anemone was in all cases firmly clasped round the leg, the edges meeting closely in the manner of *Adamsia palliata.* The anemones remained in this position for some days, but only one was left after about a month. Though the crab was not actually seen to place the anemones on his legs, there can be little doubt that such was the case, both because the anemone's power of locomotion is but small, and because of the well-known habit of Maia to "dress" itself with anything available. On the other hand cases are known where the anemone, whether as embryo or adult, selects its own habitat. Last summer in the aquarium a particularly fine specimen of *A. Rondeletii* was fixed on the back of a large live *Buccinum undatum ;* and under the same head probably fall the *Rondeletii* on the cephalothorax of *Carcinus mœnas,* instances of which are occasionally dredged in the Sound. In another tank where *Pagurus Bernhardus* with Adamsia were stored, when the anemones were fed the hermit-crabs were frequently observed to insert a chela into the stomatodæum of the anemone associated with another crab, and to drag out and devour the plunder. Mr. Bateson recorded some time ago in this Journal that he had noticed a prawn rob an *Anthea* in this way, and the observation has been since repeated.

Among the foes of shrimps, which seem to include nearly every animal in the sea, I am not aware that the common prawn has ever been recorded. Where a tub full of shrimps has been emptied into a tank for food, the prawns collect round the spot, and seize and devour at leisure live shrimps, despite their struggles. It would hardly be anticipated that the prawn would prove so deadly an enemy to an animal which seems almost as swift and as strong as itself. Shrimps are almost the only animals eaten alive in the tanks; very few of the creatures even attack each other.

The commonest Plymouth star-fish, *Asterias glacialis,* was observed to eat, not only the Mollusca supposed to form its chief food, but also *Asterina gibbosa* (Aquarium and Wembury Bay), *Echinus miliaris* (Aquarium), and small Crustacea such as *Porcellana platycheles* and *Portunes,* sp. (Wembury Bay); the latter were sometimes found reddened as if boiled, apparently by the action of the digestive juices. In all these cases the stomach was more or less everted round the food.

Like the oyster, *Pecten maximus,* when surprised, can punish an invader by nipping him tightly between its valves till he dies; an intrusive Conner (*Ctenolabrus rupestris*) was caught in this way by the head in the aquarium, and in the morning was dead.

G. H. Fowler.

2. **Grayling and Loch Leven Trout in Salt Water.**—Some time ago I received a consignment of the above-mentioned Salmonidæ from O. Greig, Esq., who has recently built large fish-ponds at Holdsworthy, N. Devon. The fish were all young, averaging about 4½ inches in length; they were transported in a conical tank of the Howietown pattern, and arrived, with one exception, in a perfectly healthy condition.

One grayling and one trout were first of all taken, and, as an extreme experiment, transferred to pure salt water. They immediately darted off with great rapidity, swimming now round the tank, now with sudden zig-zag bounds after the manner of Mysidæ. If at any time they came to rest they floated quickly to the surface, owing to their bodies being unaccustomed to so dense a surrounding medium.

Their breathing can only be described as violent spitting, and a slight quiver of the body was occasionally noticeable. Both fish soon showed signs of sickening, their motions becoming slower, and their power of keeping below the surface in a normal position less. In about two hours the grayling died, but the trout, with greater tenacity to life, remained alive for four hours.

The rest of the fish were put into water only slightly salt, and

were treated with care, the density being allowed to increase very gradually. For some days it was found that whenever the hydrometer registered 15°, the fish showed signs of distress. On the fresh water tap being alone allowed to run the majority revived, but four died even with this amount of salinity. The snow storm of March 10th occurred at this juncture, and for four days our fresh-water supply was entirely cut off. I aërated the water and only introduced small jets of salt water at intervals, but the mortality became seriously high, and the renewal of the water-supply left me with only three fish, all trout. The trout have all along proved more hardy than the grayling.

The fish commenced to feed first of all on small earthworms, but by soaking marine worms in fresh water previous to feeding, I have managed gradually to accustom them to a sea-animal diet.

The remaining trout were successfully kept alive while the water was increased in density. They are now in ordinary sea water of 26° sp. gr., and still they appear to be perfectly healthy, and are feeding well. The gradual transition from fresh water into salt has occupied just fifteen days. If they continue to thrive it will be instructive to observe their development, although we can scarcely hope that they will propagate their species.—DIRECTOR.

3. **Eels and Sticklebacks in Sea Water.**—Three eels and quite a number of sticklebacks, caught in the brackish water at the mouth of the Cattewater, are now thriving perfectly amongst the marine animals in the large exhibition tanks of the Aquarium.—DIRECTOR.

4. **Phoronis at Plymouth.**—Since *Phoronis* is not usually considered to be at all common on the British coasts, it may be useful to record the fact of its occurrence in Plymouth Sound. *Actinotrocha*, the larva of *Phoronis*, has been frequently taken here by means of the surface net (see Mr. Bourne's report, this Journal, N.S., vol. i, 1889, p. 9), but the adult animal was not observed until October last. While looking over some stones dredged near the Duke Rock, I was struck by the appearance of a number of delicate, membranous, sand-covered tubes, attached in crevices of some of the stones, and slightly projecting from the general surface. Upon placing these stones in a vessel of sea-water, the inhabitants of the tubes extruded the anterior portions of their bodies and displayed each the beautiful lophophore characteristic of *Phoronis*. The number of tentacles slightly exceeded sixty, and the lophophore was in all cases hippocrepian in form; there were no young individuals. The species was *Phoronis hippocrepia*, Str. Wright.

About the same time, Mr. Rupert Vallentin informed me that he

had found *Phoronis* in abundance at Falmouth, and kindly sent me several specimens. Mr. Vallentin's specimens closely agree with those taken at Plymouth and are undoubtedly of the same species.

Thus, *Phoronis hippocrepia* has been taken at the following parts of the British coast:—Ilfracombe (Strethill Wright), Tenby (Dyster), Sheerness (Shrubsole, species?), Millport (Kölliker), Falmouth (Vallentin), and at Plymouth. If *P. ovalis* is an immature condition of the same species, then the Firth of Forth must be added to this list.

The larva *Actinotrocha* is recorded from Plymouth (G. C. Bourne), Cromarty Firth (J. T. Cunningham), Arran (Herdman, Carpenter, and Claparède), Portobello (Spencer Cobbold), in and off the Firth of Forth (McIntosh).—Walter Garstang.

5. **Oyster Culture in the River Yealm.**—With regard to the observations on oyster culture in the river Yealm, to which reference has been made in a previous number of the Journal, a report has been furnished by Dr. G. H. Fowler to Lord Revelstoke, who had generously placed the river at the disposal of the Association, and had provided a stock of parent oysters. As a result of these experiments it appeared that (1) as regards food, the river is well adapted for the production of a fat and well-flavoured oyster; (2) that the purity and salinity of the water are also favourable; (3) that a large part of the present bottom and sides of the river are unusually well-fitted for oyster farming, and a good deal of ground, at present unfit for the purpose, could be brought into cultivation without great trouble; (4) that the considerable movement of the water in ebb and flow is a less favourable factor in the problem, but is not so extensive as to nullify the other advantages of the river for oyster farming.

6. **Ray's Bream.**—On March 28th Mr. Dunn, of Mevagissey, sent to the Laboratory a specimen of Ray's bream, *Brama Raii*, Bl. Schn. It was 50·4 c.m. in length and in a quite fresh uninjured condition. Mr. Dunn stated that it was seen swimming at the surface of the water off the beach at Portseathoe near Falmouth, and was captured with a gaff. This fish is rarely taken, and its normal habits are not well known. The occasional specimens which have been taken have been thrown up on the shore after storms, or found in an exhausted condition in shallow water. It has occurred on various parts of the British and Irish coasts. The last specimen found on the south coast was captured on June 12th, 1875, near Penzance, and is recorded by Mr. Cornish in the *Zoologist* for that year.—J. T. C.

Journal of the Marine Biological Association.

Report of the Council, 1890-1891.

During the past year the Council has met ten times for the conduct of the business of the Association.

In accordance with Bye-law 5, which provides for the election of officers, Prof. E. Ray Lankester was elected in the course of the year to the office of President in succession to Prof. Huxley, and Dr. G. H. Fowler to that of Honorary Secretary. No other changes have occurred in the Council.

The Council desire to express their indebtedness to the courtesy of the Royal Society in permitting the meetings of the Association to be held in their rooms.

Buildings, Fittings, Aquarium, &c.

The buildings at Plymouth are now in thorough repair. In the course of last summer the bottoms of the two largest tanks showed signs of weakness, the slate beams on which they rested being inadequate to support the enormous weight of water; the danger was fortunately discovered in time, and has been permanently averted by the building up of brick piers from below. A small shed has been erected at the back of the Laboratory for the reception of a forge and anvil, by the aid of which the engineer is now able to effect all minor repairs to the gas engines and steam-launch. Both gas engines have lately been thoroughly overhauled, and are working with little or none of the vibration which originally threatened danger to the vulcanite pipes. A twelfth compartment has recently been fitted up in the Laboratory for physical work.

The severe winter produced a noticeable effect on the animals in the aquarium as well as on those in the Sound, and the mortality has been considerable. The condition of the tanks is, however, annually improving, and a self-sown fauna, including Hydroids, Ascidians, and Chætopods, is slowly springing up. A small charge for admission to the aquarium, which is now open daily, has lately been instituted with satisfactory results.

Boats.

The only addition to the boats during the year is a small dinghey. The steam-launch "Firefly," purchased in July, 1889, while very economical when in working order, is a considerable source of expense for repairs, and great inconvenience was caused

during the summer of 1890 by her breaking down when the Laboratory was full of workers. The terrible storm which swept over the west of England on March 9th last did extensive damage both to the "Firefly" and to the "Anton Dohrn," since repaired; the three-ton dandy "Mabel," which fortunately escaped injury on that occasion, is also in working order.

ary. Considerable additions have been made to the Library during the year, the most important of which consists of the large and valuable collection of works on Crustacea belonging to the late C. Spence Bate, Esq., F.R.S., which have been presented by Captain McGuire Bate. Among other valuable donations are the following:

	Presented by
Bull. and Mem. Mus. Comp. Zool., Harvard College	Prof. Agassiz.
Proc. and Phil. Trans., Royal Society of London	The Society.
Mem. Roy. Acad. of Copenhagen	The Academy.
Bull. and Rep. United States Fish Commission	The Commission.
Journ. Royal Microscopical Society	The Society.
Results of the Norwegian North Atlantic Expedition	The Commission.
Quarterly Journal of Microscopical Science	Messrs. Churchill.
Mittheil. Zool. Station in Neapel	Dr. Anton Dohrn.
Bull. Scientifique de France et de la Belgique	Prof. Giard.
Mittheil. deutscher Fischerei-Verein	The Society.
Notarisia	Dr. Moreños.
Ber. Kommission wissensch. Untersuch. deutschen Meere	The Commission.
Proc. and Bull. United States National Museum	The Museum.
Tijdschrift Nederlandsche Dierkund. Vereeniging	The Society.
Journal of the Linnæan Society	The Society.
Bergens Museum Aarsberetning	The Museum.
Journal of the College of Science, Tokyo	The College.
Trans. Royal Society of Edinburgh	The Society.

The Council beg to tender the thanks of the Association to the donors of these and of many other publications.

Staff. At the end of July last Mr. G. C. Bourne tendered his resignation of the post of Director of the Laboratory to the Emergency Committee, and Dr. G. H. Fowler was appointed *ad interim* Director for the summer months. At a special meeting held on November 14th Mr. W. L. Calderwood was appointed to succeed Mr. Bourne, and entered on his duties on November 29th. The Director's Assistant, Mr. Walter Garstang, M.A., resigned in December last to take up a Research Fellowship at the Owens College, Manchester; and Mr. Calderwood has appointed Mr. H. N. Dickson, F.R.M.S., F.R.S.E., in his place. Mr. F. Hughes, of the Finsbury Technical College, has been recently appointed to carry out an inquiry from the chemical side into the possibility of manufacturing an artificial bait for long-line fish-

ing. The funds for this purpose have been provided by the generosity of Mr. Robert Bayly, of Plymouth.

The following gentlemen have occupied tables in the Laboratory during the past year for the prosecution of their private researches, some of them on more than one occasion :— Occupation Tables for private research.

Mr. W. B. Benham, D.Sc. (*Polychæta*).
Mr. Hans Driesch, Ph.D. (Heliotropism in *Hydroidea*).
Mr. G. H. Fowler, B.A., Ph.D. (Variation in *Isopoda*).
Mr. W. Garstang, M.A. (*Ascidiacea*).
Prof. T. Johnson, B.Sc. (*Algæ*).
Mr. E. A. Minchin, B.A. (*Porifera* and *Gregarinida*).
Mr. T. H. Riches, B.A. (*Pagurida*).
Mr. W. G. Ridewood (*Clupeidæ*).
Mr. W. W. Welch (General Zoology).
Prof. W. F. R. Weldon, M.A., F.R.S. (*Decapoda*).
Mr. M. F. Woodward (*Mollusca*).

The first volume of the new series of the Journal of the Association has been completed. The quarto Treatise on the Common Sole by Mr. Cunningham, the Naturalist of the Association, was published in October last. Publication.

Prof. E. Van Beneden, of Liège, has recently published a memoir on specimens of the interesting larval Anthozoan, *Arachnactis*, which had been collected at Plymouth by the Director, and forwarded to Prof. Van Beneden at his request (Archives de Biologie, xi, p. 115).

The most important investigations in connection with fisheries are those carried out by Mr. Cunningham. A point to which he has lately paid considerable attention is the rearing of post-larval forms in the aquarium. This research, when taken in conjunction with observations made by trawling, is yielding valuable information on the rate of growth and the age at which sexual maturity is attained. Information on these points is a necessary preliminary to the serious consideration of any such prohibitory legislation as has lately been demanded. Mr. Cunningham is also continuing his inquiries into the localities frequented by immature fish in the Plymouth area. Fishery investigations.

A series of careful experiments into the suitability of the river Yealm for purposes of oyster-farming were made during 1890 by Mr. Bourne and Dr. Fowler; and a report embodying their results and recommending its employment for such purposes has been furnished to Lord Revelstoke, the lessee of the river.

Further experiments on the rearing of larval lobsters, with the view of keeping them in safety through the first moults, instead of turning them free in the sea at what appears to be their most helpless phase, have been carried out under the superintendence of Prof. Weldon; the difficulties in the way being apparently the provision

of adequate space and of an appropriate food. As regards the question of space, it is most desirable that, for the purposes of rearing both lobsters and fish, the Association should form an enclosed pond within reach of Plymouth; but the peculiar features of the coast render it extremely difficult to find a site which can be made available except at considerable cost.

Dr. Grenfell, the Medical Superintendent of the Mission to Deep Sea Fishermen, has consented to extend the observations which he has already taken in the North Sea so as to include points bearing on the proposed closure of certain extra-territorial waters to beam-trawlers, which was discussed at the International Conference of 1890; he has been furnished with thermometric and other apparatus, and with printed forms for the systematic record of the numbers and sizes of fish taken on the various grounds.

The same reasons which make it difficult to find a suitable site for a rearing pond for young fry in the neighbourhood of Plymouth have hitherto prevented the establishment of a pond for growing immature soles, &c., to a marketable size. The Director has lately paid attention to the matter, but no place combining the numerous requirements for success has been as yet found within an accessible distance of Plymouth.

So many anchovies were brought to the Laboratory in the course of last winter, in consequence of a price having been offered for them by the Association, that the Council has authorised the construction of an anchovy drift-net on the most approved model at a cost of about £60. The fish ordinarily caught appear to be exceptional specimens, large enough to be taken in a pilchard net, and it is expected that, by the use of the special net, the occurrence of anchovies in sufficient numbers to justify a regular fishery will be demonstrated.

Among other extensions of the work of the Association during 1891, it may be mentioned that a series of systematic physical observations will in future be carried out by Mr. Dickson, which may be brought to bear on various questions connected with fisheries.

The usual hatching and breeding experiments have been continued.

Finance. The receipts of the past year including the annual grants from H. M. Treasury (£500), and from the Worshipful Company of Fishmongers (£400) amount to £1925 5*s.*; the annual subscriptions and composition fees produced £273 9*s.*, the interest on investments £35, the rent of tables £85, the sale of specimens £148 17*s.* 11*d.*, the charge for admission to the aquarium (since February 11th, 1891) £30.

A comparison of the chief items with the corresponding amounts of last year

	1889–90.		1890–91.
Annual Subscriptions and Composition Fees	£143 13 0	...	£273 9 0
Founders' Subscriptions	300 0 0	...	100 0 0
Rent of Tables and Sale of Specimens	185 5 0	...	240 19 11

shows an increase in the subscriptions of Annual and Life Members, and also points to an increased use of the Laboratory by the public both for original investigation and for the obtaining of material for teaching purposes. On the other hand only one Founders' subscription has been received during the year.

The Council are glad to be able to announce that in addition to the £500 annually granted (during a period of five years) to the Association by H.M. Government, a further sum of £500 has been placed on the estimates for the current financial year.

Mr. J. P. Thomasson, M.P., has generously offered the sum of £250 for expenses incurred in carrying out observations bearing on the closure of certain extra-territorial waters to beam-trawlers by international convention. It is proposed to take advantage of his offer immediately.

The Council have recently taken steps to bring the claims of the Laboratory and its work under the notice of the Technical Education Committees of the County Councils of the South Coast of England.

The Officers and Vice-Presidents proposed by the Council for the year 1891–92 are:

PRESIDENT.

Prof. E. Ray Lankester, LL.D., F.R.S.

VICE-PRESIDENTS.

The Duke of Argyll, K.G., F.R.S.
The Duke of Sutherland, K.G.
The Duke of Abercorn, C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
Lord Walsingham, F.R.S.
Lord Revelstoke.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
Prof. G. J. Allman, F.R.S.
Sir Edward Birkbeck, Bart., M.P.
Prof. Flower, C.B., F.R.S.
Sir John Lubbock, Bart., M.P., F.R.S.
Prof. Alfred Newton, F.R.S.
Sir Henry Thompson.
Rev. Canon Norman, D.C.L., F.R.S.
Captain Wharton, R.N., F.R.S.
J. P. Thomasson, Esq.

COUNCIL.

Elected Members.

Prof. F. Jeffrey Bell, F.Z.S.
Frank Crisp, Esq., V.P. and Treas. Linn. Soc.
W. T. Thiselton Dyer, Esq., C.M.G., F.R.S.
John Evans, Esq., D.C.L., Treas. R.S.
Prof. J. C. Ewart, M.D.
A. C. L. G. Günther, Esq., F.R.S.
Prof. A. C. Haddon, M.A.
E. B. Poulton, Esq., F.R.S.
P. L. Sclater, Esq., F.R.S., Sec. Z.S.
Adam Sedgwick, Esq., F.R.S.
Prof. Charles Stewart, P.L.S.
Prof. W. F. R. Weldon, F.R.S.

Hon. Treasurer.

E. L. Beckwith, Esq.

Hon. Secretary.

G. Herbert Fowler, Esq., B.A., Ph.D.

June 24th, 1891.

DR. *Statement of Receipts and Payments for Year ending* 31*st May*, 1891. CR.

RECEIPTS.	£	s.	d.	£	s.	d.
To Balance from last year, made up as follows:						
Special Fund, Bait Investigation	387	9	9			
„ Steam Launch	90	4	0			
	477	13	9			
Less Deficit on General Account	204	10	10			
				273	2	11
To H. M. Treasury				500	0	0
„ Fishmongers' Company				400	0	0
„ Donation, J. P. Thomasson, Esq.				250	0	0
„ Annual Subscriptions				211	4	0
„ Founders				100	0	0
„ Composition Fees				62	5	0
„ Rent of Tables, Sales of Journal, Specimens, &c.	240	19	11			
„ Sales of Monograph on the Sole	96	1	6			
„ Admission to Tank Room	29	12	7			
„ Interest on Investment	35	2	0			
				401	16	0
				£2198	7	11

PAYMENTS.	£	s.	d.	£	s.	d.
By Salaries and Wages:						
Director	200	0	0			
Naturalist	250	0	0			
Wages and Salaries of Assistants, &c.	384	14	0			
				834	14	0
By Stationery, Office Printing, Postage, &c.				162	9	1
„ Printing and Illustrating Journal				114	4	3
„ Printing and Illustrating Monograph on the Sole				282	10	8
„ Gas, Water, Coal, Oil, &c.	116	6	5			
„ Stocking Tanks with Fish, Feeding and Maintenance	89	2	5			
„ Glass, Chemicals, Apparatus, &c.	135	3	5			
„ Maintenance and General Repairs	105	7	11			
„ Rates and Taxes	34	3	9			
„ Boat Hire	49	4	8			
„ Travelling Expenses	32	2	7			
„ Library	25	6	7			
„ Lecture Fund	7	5	5			
				594	13	2
By Balance forward, made up as follows:						
Special Fund, Bait Investigation	387	9	9			
„ Steam Launch	90	4	0			
	477	13	9			
Less Deficit on General Account	267	17	0			
				209	16	9
				£2198	7	11

Investment held 31st May, 1891:
£900 Forth Bridge Railway 4% Debenture Stock at 125...£1125 0 0

Examined and found correct,

C. STEWART,
P. L. SCLATER,
EDWIN WATERHOUSE, } *Auditors.*

22*nd June*, 1891.

Annual General Meeting, 1891.

The Annual General Meeting of the Association was held in the rooms of the Royal Society on Wednesday, June 24th, 1891, the President, Prof. E. Ray Lankester, LL.D., F.R.S., in the Chair.

The minutes of the last General Meeting having been read and confirmed, the Report of the Council was read, and was adopted on the proposal of Admiral Sir Erasmus Ommanney, C.B., F.R.S., seconded by Dr. S. J. Hickson.

The Report of the Hon. Treasurer, and the Balance Sheet were also adopted on the proposal of John Evans, Esq., D.C.L., Treas. R. S., seconded by Prof. Weldon, F.R.S.

The Hon. Treasurer then moved a vote of thanks to the Rt. Hon. Joseph Chamberlain, for his valuable services to the Association during the past year, which was seconded by Prof. McIntosh, F.R.S., and carried unanimously.

The list of the Officers and Council suggested by the Council for the year 1891–92 having been proposed by Dr. S. J. Hickson, and carried, Prof. Flower, C.B., F.R.S., moved a vote of thanks to Mr. J. P. Thomasson for his offer of £250 for expenses to be incurred in carrying out observations in the North Sea, which was seconded by the Hon. Treasurer, and carried unanimously.

The proceedings concluded with a vote of thanks to the Officers and Council, proposed by Prof. M'Intosh, and supported by Admiral Sir Erasmus Ommanney.

Director's Report.

During the summer months the tables of the Laboratory were well occupied; the following is a list of the workers, together with the subjects studied:

Garstang, W. .	. Tunicates.
Buchanan, Miss .	. Polychætes.
Stewart, A. H. .	. Holothurians.
Gamble, F. W. .	. Eyes of Mollusca.
Weldon, W. F. R.	. Crangon.
Robinson, Miss .	. Palæmon.
Ritches, J. H. .	. Pagurus and Hormiphora.
Willey, A. .	. Tunicates.
Hughes, W. J. .	. General Natural History.
Hamel, E. de .	. General Natural History.
Hickson, S. J. .	. Alcyonium.

The weather has been extremely unfavorable for carrying on continuous and systematic dredging; nevertheless the boats of the Laboratory have been constantly employed on every suitable day, and a considerable amount of material has been collected.

The preservation of specimens has been much more carefully attended to than formerly. One man now devotes almost his entire time to this work. This is necessary, since it is only by constant practice in the treating and handling of delicate specimens that really satisfactory results can be attained. Our trade in specimens is now becoming extensive, and it is therefore highly desirable, both for the credit of the establishment and for its purse, that the material supplied should be prepared with the utmost care.

Mr. Cunningham continues his valuable observations on the rate of growth of food fishes, also on their life histories and spawning periods. Papers by him will be found in the present number treating on these subjects.

Experiments on the production of artificial baits are also being continued by Mr. Hughes. He has also been making some interesting experiments as to the presence of fat in the flesh of fishes,

particularly those fishes which are prepared for the market by drying.

A meteorological station of the second order has been established, where observations are taken twice daily. This, in addition to the ordinary physical work of the Laboratory, is under the supervision of Mr. Dickson.

The presence of anchovies in considerable numbers in the waters of the Channel has from time to time been taken notice of;* and now, in order to demonstrate as far as possible the actual numbers, and the possibility or otherwise of instituting a regular anchovy fishery, a fleet of small-meshed nets has been specially constructed.

Owing to the very boisterous weather we have only been able to shoot the nets three times, and as yet have not been successful in coming upon anchovies.

Arrangements for a still larger Fishery Investigation have been made. The Association has determined to make a thorough examination into the actual condition of the North Sea Trawling Grounds, the International Conference of July, 1890, having abundantly proved that reliable data were required before any legislation could, with confidence, be expected; and at the same time that international legislation was demanded on all sides, owing to the general outcry that the grounds are over-fished, and that large quantities of sexually immature fish are constantly being captured or destroyed. Mr. Holt, at present engaged in Irish Fishery duties, has been specially appointed to carry on this work during the ensuing year. I shall not at present enter into a detailed statement as to how it is proposed to investigate the question, but shall probably, in the next number of the Journal, give an account of the lines on which the work has actually been begun. I have already made the various headings in the scheme of work public, by including them in a general paper on the work of the Association read to the Biological Section of the British Association this year.

I need only add that the general work of the staff continues steadily; that we have hatched both flat-fish and lobsters in considerable numbers in the Dannevig hatching-box, of which I spoke in my last report; that many interesting animals have been obtained—some of which are described in this number of the Journal; and that we hope to continue to increase our knowledge, both in regard to matters scientific, and in the more practical questions connected with the fishing industries of the United Kingdom.

W. L. CALDERWOOD.

* Journal Marine Biological Assoc., vol. i (N.S.), p. 328.

The Egg and Larva of Callionymus lyra.

By

J. T. Cunningham, M.A.

With Plate V.

The egg of this species has been described and discussed by Professors McIntosh and Prince, by Mr. E. W. L. Holt, and by myself.* Raffaele, in his paper in the Mittheilungen of the Naples Station, vol. viii, described the yolk in the ovum of *Callionymus festivus* as having a peripheral layer of yolk-segments, but no reticulated marking on the surface of the vitelline membrane; while all we English observers have agreed in stating that the egg of *Callionymus lyra*, our common dragonet, has a reticulated marking on the vitelline membrane, but no yolk-segments. I was, therefore, very much surprised, in examining some eggs of this species from the tow-net this year, to find that there actually was a peripheral layer of yolk-segments, which had hitherto been overlooked.

Raffaele states that in *Callionymus festivus*, the Mediterranean species, the yolk-segments extend all round the yolk from the beginning, before it has been enveloped by the blastoderm. Whether this is correct in *C. festivus* or not, it does not apply to *C. lyra*. In the ovum shown in Pl. V, fig. 1, which was taken in the tow-net on May 14th, 1891, the blastoderm has spread over about one third of the circumference of the yolk, and the layer of yolk-segments extends beneath the blastoderm and somewhat beyond it, but is absent from the opposite pole of the yolk. An egg of the same species at a later stage, in which the yolk is completely enveloped, and Kupffer's vesicle has appeared beneath the posterior end of the embryo, is shown in fig. 2, and it will be seen that at this stage the external subdivided layer extends over the whole of the yolk. Thus the layer of yolk-segments in the egg of *C. lyra* is at first confined to

* See Ann. and Mag. Nat. Hist., Dec., 1885; Memoir by McIntosh and Prince in Trans. Roy. Soc. Edinb., vol. xxxv, pt. 3, 1890; my paper in this Journal, vol. i, p. 21; Mr. Holt's Memoir in Sci. Trans. Roy. Dublin Soc., vol. iv, ser. 2, No. 7.

the part of the yolk beneath the blastoderm, and accompanies the latter in its gradual extension, just as in the eggs of *Solea* and in other cases where the peripheral yolk-segments occur.

There can, I think, be no doubt about the identification of the eggs I refer to. I have never found in the egg of any other species anything resembling the hexagonal reticulation in the membrane of the egg of the dragonet. The size of the eggs described here was ·81 and ·83 mm. in diameter, while those described in my former paper measured ·90 and ·97, a variation not greater than that which occurs among the eggs of a given species.

Mr. Holt (loc. cit.) has given figures of the larval dragonet when just hatched, and about twelve hours after hatching. I am able now to give a figure of a later stage. The larva depicted in fig. 3 was drawn on May 14th, and hatched from an egg taken on May 6th, so that it was probably five or six days old. The yolk is entirely absorbed, but the larva retains some of the characteristics mentioned by Holt. There are marginal pigment spots on the embryonic fin-fold, but they are more numerous than in the stage figured by Holt; while there is no band across the tail, but pigment over nearly the whole of the post-anal portion of the body. The pectoral fin is large. The snout has still a somewhat pointed form, but the region of the mid-brain is much more prominent than in Holt's stage. Holt speaks of only one pigment, a bright orange, dark by transmitted light, and I gather from his description that in the stages he examined he saw no black chromatophores. I think this must be a mistake; in any case there are, as usual, both black and coloured chromatophores in the stage I am describing, the coloured cells being light yellow by reflected light and darker yellow by transmitted. The length of the larva was 4·7 mm.

DESCRIPTION OF PLATE V,

Illustrating Mr. Cunningham's paper on "The Egg and Larva of *Callionymus lyra*."

FIG. 1.—Egg of *Callionymus lyra*, taken May 14th, 1891. Zeiss A, Oc. 3. Under cover-glass, drawn with Abbé's camera lucida.

bl. Blastoderm.

y. s. Yolk-segments.

FIG. 2.—Another egg at a later stage of development. Drawn with the same combination, without cover-glass.

k. v. Kupffer's vesicle.

y. s. Yolk-segments.

FIG. 3.—Larva of same species some days after hatching. Drawn May 14th, 1891. iss a_3, Oc. 3, camera.

Fig. 1.

Fig. 2.

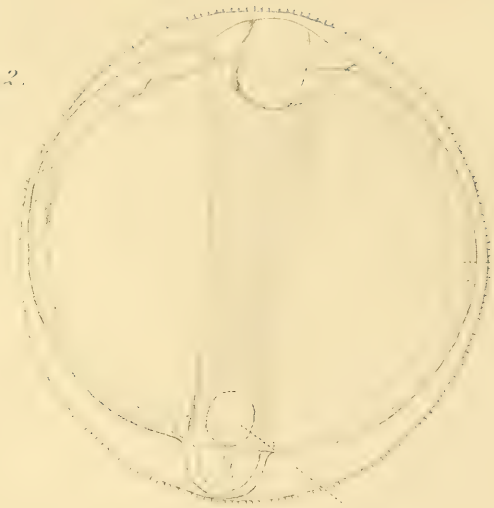
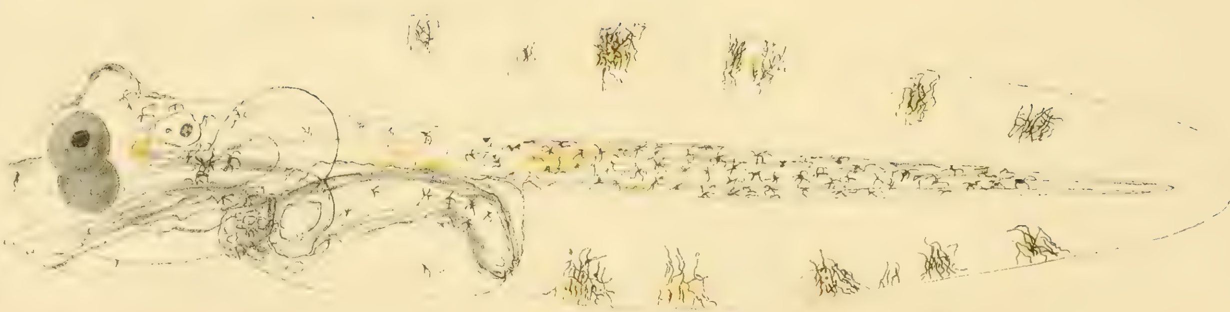


Fig. 3.



J. T. Cunningham del.

F. Huth, Lith. Edin.

Experiments on the Production of Artificial Baits.

By

Frank Hughes.

It may be well to preface the paper on the *Production of Artificial Baits* by a short statement as to the way in which the experiments were taken up by Mr. Hughes.

Members of the Association are of course aware that, through the kindness of Mr. Bayly, of Torr Grove, Plymouth, a special fund was instituted for the purpose of finding out, first of all, what it was in the bait that attracted fish, and, secondly, how the attracting matter could artificially be extracted, and applied to easily procured substances; or manufactured altogether afresh.

The papers of Mr. Bateson, published in the Journal, vol. i, No. 3, discussed, at considerable length, the manner in which fish sought their food by the action of their various senses. This work formed a logical basis for the whole inquiry of artificial bait, besides proving of great scientific value.

The question has now been taken up from a chemical point of view, and practical results sought after. This preliminary paper by Mr. Hughes—a chemist from Prof. Meldola's Laboratory—shows generally the methods he has employed in trying to produce an artificial bait from natural sources.

When several preparations had been made, a long line was set somewhere in the neighbourhood of Plymouth, the hooks being baited, not only with the newly prepared substances, but with natural baits as well, so that a proper estimate might be formed by comparison.

Briefly, it may be said, that no bait has yet been discovered which appears to act as an irrestible lure to the fishes, but at the same time a considerable amount of success has been met with, and if the

difficulty of finding a proper medium with which to convey the attracting smell could only be got over the problem would practically be solved.—W. L. CALDERWOOD, *Director.*

In a previous number of the Journal Mr. Bateson has shown that the majority of the fishes which are caught by the long lines are attracted to their food entirely by smell, and it has been suggested that if the odorous material could be extracted from the bait and preserved, it would be possible to keep a supply of such bait in hand, and so be more or less independent of the supply of natural bait, which is at all times very uncertain. My first experiments were mainly in this direction, to extract and preserve the odorous matter from the bait, and in this I have been to some extent successful.

Various solvents were employed for extracting. The volatile ones, such as ether and chloroform, were used in an extracting apparatus, while in other cases the bait, &c., was cut into small pieces and soaked in the liquid at as high a temperature as could be employed without destroying the scent. This temperature appears to be about 50° C. Ether extracts from almost all kinds of bait an oil, varying greatly in quantity; from squid and mollusca; generally this amount is extremely small and on this account quite useless, although it has in some cases attractive properties. Pilchards and mackerel give a relatively large amount of extract, owing to their oily nature; but although these are to some extent attractive, they do not appear to contain anything like the total amount of odorous matter present in the animal. *Nereis* and *Arenicola* (as worm baits) give ethereal extracts which are attractive to some fish—turbot, rockling, pouting, &c., but the conger is not attracted by them. Chloroform extracts nothing from mollusca, and in no case was an extract having attractive properties prepared with this solvent. Olive oil and fats do not take up the scent from any of the baits mentioned. Distillation of the baits in water, or in a current of steam, only gives a smell of cooked fish, which is utterly unattractive.

Besides extracts of the baits usually employed, I have also prepared some from coarse fish; from the intestines, livers &c., of ling, and hake, and from the hermit crabs; but have not succeeded in obtaining anything at all attractive, and I believe that, if any efficient extract is to be prepared, it must be from squid, mackerel, or pilchard. The most attractive extracts are those prepared with glycerine, but they have the disadvantage that the solvent cannot be recovered or got rid of; but, on the other hand, they can be kept for any length of time if some boracic or salicylic acid be dissolved in the glycerine.

When a sufficiently attractive extract is obtained, however, it does not necessarily follow that it is of any use as a bait, since there is a great difficulty in applying anything in a liquid form. To do this, some substance is needed which will soak up enough extract to retain its odour for a sufficient time in the water, and yet be soft enough to allow of the fish getting hooked. Various substances have been tried for this purpose. Pieces of flannel and bags of buttercloth filled with pulp or cotton-wool, were soaked in the extracts, but these do not retain their smell more than a few minutes. To obviate this, I tried to thicken the extracts with gelatine, but this appears to precipitate the odorous substances, and the smell is destroyed. Slices of turnip, filled with the extract under reduced pressure, were also tried; but in this case a strong vegetable odour was developed, which rendered the substance useless. Gelatine appears at first to be just the substance required, but in order to mix the extract with the gelatine heat must be applied, and this completely destroys the smell of the extracts.

Since liquid extracts appeared to be so difficult to use as bait, I tried making a kind of mash of the bait, adding small quantities of boracic acid and glycerine, to prevent decomposition. These mixtures remain unchanged for a considerable length of time, and retain their attractive properties.

Mackerel and squid treated in this manner were most attractive to the conger in the tanks of the Laboratory, but I have not caught any fish with them from the sea, although some of the bags containing the mixtures have been sucked off the hooks. Conger will also eat pastes made with flour and these mashes; but these are of no use for fishing, as they do not remain on the hooks for a sufficient length of time. If one may judge from experiments in the Aquarium, as soon as a bait reaches the bottom it is seized by the crabs, and if it is not sufficiently tough, is pulled off the hook before the fish have time to get the scent. For this reason the medium for applying an extract, or, in fact, almost any kind of preparation must be exceedingly strong, and not easily pulled to pieces. If anything of this nature can be prepared, the application of extracts will become easy, and the whole question will be very much simplified.

I have not made any experiments with essential oils, since Mr. Bourne, when at Plymouth, tried several of these, and found that none were in any way attractive; it seems improbable that fish would be attracted by anything of that nature, since, in the natural course of events, they would never meet with such bodies.

Preserving bait by freezing has also been tried, and was moderately successful. A number of squid were cleaned and placed in an air-tight jar, a small quantity of dry boracic acid, being

sprinkled over them ; this jar was then surrounded with a mixture of ice and salt, so that the temperature did not rise above 28° F. At the end of about a fortnight the jar was opened, and the water which had accumulated at the bottom poured out ; the jar was again closed and kept for three weeks in ice ; the squid was then of a pink colour, but was quite fresh, and fifty hooks baited with it caught four conger, while fifty with natural bait caught only one conger and two pollack. This shows conclusively that squid can be kept for a considerable time in a frozen condition, and, if this process could be carried out on a larger scale, with refrigerating apparatus, the expense need not be very great. I intend to try if pilchards can be preserved in a similar way. This has been attempted, but the temperature was allowed to rise too high, and decomposition occurred.

The Rate of Growth of some Sea Fishes and their Distribution at Different Ages.

By

J. T. Cunningham, M.A.

Dr. Wemyss Fulton has made an extensive investigation of the distribution of immature sea fishes, and has published his results in the Report of the Scottish Fishery Board for the year 1889. He had at his disposal a sea-going vessel specially adapted to fishery investigations, and his data were obtained exclusively by means of this vessel. As scientific Secretary to the Board Dr. Fulton is attached to the Office in Edinburgh, and the observations he required were made and recorded according to his directions by the naturalists on the Board's steamer "Garland." The conception and the execution of this investigation are both admirable, and it has supplied a great deal of definite knowledge upon subjects of great importance on which previously we knew little or nothing. The enquiry consisted in determining firstly, from the examination of a large number of specimens, the minimum and maximum size of sexually ripe specimens of each species; and secondly, the relative abundance of specimens smaller than this minimum size at various depths and various distance from shore.

The enquiries described in the present paper are to some extent similar to Dr. Fulton's, but in the main they are different both in object and in method. My first object was as far as possible to ascertain something of the rate of growth of sea-fishes of various species. With this purpose, I have searched for young specimens in all possible ways, and have measured and preserved all I could meet with. Some have been taken with the shrimp-trawl worked from our little steam-launch in Plymouth Sound and the neighbouring bays, some in the tow-net. I have also collected specimens from the deep-sea trawl of the professional trawlers, and from the hauls of ground seines. During the summer of the present year, I have been authorised to hire steamers in order to collect in deep water at some distance from land, and have trawled at various

depths with the shrimp-trawl and a small-meshed otter-trawl, and have also worked a large tow-net, 8 feet by 6 feet in area at the mouth, at various distances from the coast. Knowing the spawning time of each species I have been able to determine the age of the young specimens collected in a number of cases with more or less certainty. Often there is no doubt as to the age within a month or so of young specimens of the same year's brood, and it is often possible to say that small fish which are too large to be derived from the last spawning period, for instance those collected at the spawning period itself or a little later, must be a year old or a little over. But it is difficult in this way to ascertain the maximum growth for one year, since a number of specimens of one species often form a continuous series in size, and it becomes difficult or impossible to say where those of one year old end and those of two years begin.

In order to get more certainty on the question, I have been rearing specimens of known age of as many species as possible in the tanks of the aquarium. The first results of these experiments were published in this Journal, vol. i, p. 370. Many of the flounders and other fish mentioned there are still alive. It is, of course, a question in the case of each species how far the growth of specimens in captivity is normal, whether it exceeds or falls short of the growth of those living in the free state. This question can only be answered by comparing the size of captive specimens with that of young specimens collected from the sea at various times of the year.

I have recorded the place of capture as well as the size of the specimens collected, and am able therefore in some cases to confirm and in others to add to the results obtained by Dr. Fulton. In a few cases I have had opportunities of determining the minimum size of ripe specimens with results which sometimes differ from Dr. Fulton's, a difference doubtless due in part to the difference of the districts in which our observations have been made.

Another subject I have discussed is the relation between age and sexual maturity. It is not at present known whether flat fishes for instance begin to breed at one year of age or at two, or whether some breed at one year and others at two according to the size they reach in the time. Some species again may have a more uniform growth than others, and all breed at the end of their first year, while other species do not breed till a later age.

I have given below, in tabular form, the details I have collected up to the present time concerning the several species. The majority of the species considered, belong to the families Pleuronectidæ and Gadidæ, and I have more data referring to the flat fishes than to any other species. With the exception of *Caranx trachurus* all the

species included in this paper are trawl-fishes. Each table is followed by a short commentary, and at the end of the paper I have summarised and compared together the results brought out by the tables.

Pleuronectes flesus, the Flounder. Specimens reared in the Aquarium.

Date.	Number of specimens.	Length in centimetres.	Length in inches.	Age.	Remarks.
May, 7, 1890	200—300	1·15—1·2	½	About 1 month to 2 months	Obtained in Mevagissey Harbour at low tide.
Aug. 19, 1890	2	6·7—8·0	2·6—3·2	4 to 5 months	Only two measured.
April 4, 1891	18	4·0—16·3	1·6—6·0	1 year	Kept in a tank 5 ft. by 2½ ft. and 1 ft. 6 in. deep.
„	20	5·0—17·4	2·0—6·9	1 year	Kept in another tank of the same size.
„	13	5·5—19·0	2·2—7½	1 year	Kept the latter part of the time in a tank 18 ft. by 3½ ft., by 2 ft. deep. The smallest weighed ¼ oz., the largest 3⅜ oz.
Sept. 1, 1891	3	17·8—20·8	7·0—8·2	1 year 6 months	Kept in a tank 2 ft. by 1 ft. in area, and died from an accident to the water.

The above table gives the growth actually observed in a large number of specimens kept in captivity and abundantly supplied with food. The most striking feature of the result is the very great variation in growth among these individuals, spawned at the same season, and therefore not differing by more than a few weeks in age. Whether there is as much variation under natural conditions is a question that immediately suggests itself. It is evident there is considerable variation in the rate of growth in nature, from the difficulty of distinguishing in a large number of fish those of one year's, two years', and three years' growth. It is not difficult to recognise with certainty young fish only a few weeks or months old; but the individuals of a given species brought up in numbers at a single haul of the great beam-trawl form usually a regular series of sizes, so that it is difficult if not impossible to separate definitely those which are one year old from those which are two, and those which are two years from those which are three.

Another point of interest is the relation of age to sexual maturity. According to Dr. Fulton's investigations, the smallest ripe flounder is 7 inches long. Now some, namely two out of fifty-one specimens, of my captive flounders had reached and passed this limit

of size in one year's growth. But these specimens were not ripe, and the proportion of specimens of this size is so small, that I think it may fairly be concluded that the flounder does not breed at the end of its first year. Of course, it is possible that the largest specimens one year old breed, while the smaller are still sexually immature ; but the evidence of my captive specimens is against this. It seems probable, therefore, that the flounder does not begin to breed until it is two years old, when its length would probably be from 7 to 9 or 10 inches. The largest flounder observed by Dr. Fulton was 16½ inches long. The increase in length per annum must of course diminish with every year of age, even if the rate of increase in weight were to remain uniform, simply because the weight is proportional to the cubic dimensions of the fish, and probably the rate of increase in weight also diminishes with age. Therefore, a flounder from 12 to 16 inches in length is in all probability at least three years old and may be many more.

Pleuronectes flesus, the Flounder. Specimens obtained from the Sea.

Date.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
May 7, 1890	200—300	1·15—1·2	½ inch	About 1 to 2 months	Mevagissey Harbour.
May 31, 1889	A number	1·1—1·9	½—¾	2 to 3 months	„ „
June 15, 1889	„	1·2—2·8	½—1·1	2½ to 3½ months	„ „
April 8, 1891	6	14·2—19·0	5·6—7·5	1 year	Taken by seine in Catwater.
Oct. 15, 1890	3	18·1—21·3	7·1—8·4	1 year 7 months	Taken by seine in Hamoaze.
	2	26·2—27·0	10·3—10·6	2 years 7 months	„ „

The data here are very insufficient, and I hope to add largely to their number in future. But I think it is evident that the flounders taken on April 8th, 1891, in the Cattewater, were just over one year old, and had grown to about the same size as the larger among the specimens kept in our tanks. It seems, therefore, that the growth of this species observed in captivity does not differ very much from that of specimens living in freedom. Whether in a state of nature specimens ever reach such a small size in one year as the smallest of my captive specimens I am as yet unable to say. But it must be remembered that the competition for food in a small tank containing a large number of specimens is very great, so that individuals which possess a little superiority in size and activity to start with, probably increase that superiority continually by seizing the greater part of the food before the smaller ones can get it. No doubt there is competition in the natural state, but at any rate the

individuals on the sea bottom have a much greater area to wander over.

With regard to distribution it is noteworthy that I have taken no flounders under 7 inches long except in the estuaries of Cattewater and the Hamoaze, although I have seen numbers of ripe flounders brought up in the trawl on the ground inside the Eddystone from a depth of 25 to 28 fathoms. Dr. Fulton also failed to find any small flounders in the results of the Garland's fishing at various depths and distances from the shore with a small-meshed trawl. It seems pretty certain that the flounder in its immature state is confined to inlets and especially estuaries, where the water is more or less brackish. It certainly spawns in the open sea up to depths of 30 fathoms; but even adults are found far up such estuaries as the Firth of Forth, and the Cattewater at Plymouth.

Pleuronectes platessa, the Plaice.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
June 13, 1889	1	5·1	2·0	4 months	Whitsand Bay, 5 to 7 fathoms. Shrimp trawl.
June 17, 1889	39	3·5—5·9	1·4—2·3	3 or 4 months	,, ,,
Sept. 28, 1889	1	6·3	2·5	6 months	Sutton Pool.
Feb. 13, 1889	2	8·0, 8·3	3·1, 3·3	1 year	Cattewater.
Feb. 26, 1889	1	9·4	3·7	1 year	Entrance of Cattewater.
Feb. 27, 1889	1	8·9	3·5	1 year	Cawsand Bay, 3 to 5 fathoms.
May 16, 1889	10	11·2—17·7	4·4—7·0	1 year and 3 months	Cattewater, in small seine.
May 24, 1889	1	15·5	6·1	,,	Cattewater.
Sept. 18, 1891	1	20·7	8·2	1 year and 7 months	5 to 8 miles S. of Eddystone, 35 fathoms.
Oct. 15, 1890	7	19·5—24·8	7·7—9·8	1 year and 8 months	Hamoaze, in small seine.
Dec. 10, 1889	1	22·4	8·8	1 year and 10 months	Cattewater.
April 19, 1891	2	25	9·8	2 years	Professional trawler, E. of Eddystone, 30 fathoms.
Sept. 8, 1891	1	22·2	8·7	1 year and 7 months	S.W. of Rame Head, 25 fathoms, otter-trawl.
,,	6	27·5—31·5	10·8—12·4	2 years and 7 months	

It may seem that I have estimated the age of the specimens in the last entry of the table too highly, but it must be remembered that the plaice reaches by no means so large a size on the south-west coast of England as it does on the east coast. In fact, in the neighbourhood of Plymouth the plaice is not very much larger than the flounder. Dr. Fulton gives the maximum size of the plaice as

28 inches, but I think 20 inches is about the maximum at Plymouth, and the usual size is 15 to 18 inches. I do not think, therefore, that this species could reach 12 inches in less than two years. My observations fully agree with those of Dr. Fulton in regard to the distribution of young plaice, all those I have obtained under 9 inches having come from Whitsand Bay, 3 to 7 fathoms, or from the estuaries opening into Plymouth Sound. The smallest ripe plaice I have seen was 25 c.m. or 9·8 inches long, and this was a male, while Dr. Fulton finds the lowest limit in size of mature individuals to be 12 inches. This again illustrates the difference with respect to this species between the south coast and the east coast.

From my results and Dr. Fulton's together I think there is very strong evidence that the plaice does not begin to breed till it is two years old (and over 8 inches long on the south coast), that for the first eighteen months of its life it resides in estuaries and inlets under 10 fathoms in depth, and that it only migrates to deeper water when it is nearly two years old, shortly before it begins to breed for the first time.

Pleuronectes limanda, the Dab.

Date.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
June 14, 1890	1	1·05	0·4	About 3 months	Cawsand Bay, 3 to 5 fms.
June 17, 1889	11	3—3·4	1·2—1·4	,,	Whitsand Bay, 5 to 7 fms.
June 25, 1889	7	1·7—3·2	0·7—1·3	,,	Cawsand Bay.
July 9, 1891	2	1·6—1·7	0·6—0·7	,,	Two miles N. of Eddystone, fine meshed shrimp trawl.
Sept. 4, 1890	8	3·3—5·1	1·3—2	About 6 months	W. of Rame Head, 20 fms.
Oct. 3, 1889	1	3·6 ,,	1·4	About 7 months	Cawsand Bay.
Dec. 10, 1889	5	5·7—11	2·2—4·3	About 9 months	Cattewater.
Feb. 13, 1890	7	2·6—9·5	1—3·7	About 11 months	Cattewater.
Feb. 27, 1890	2	5·7, 6·1	2·2, 2·4	,,	Cawsand Bay.
Apr. 3, 1891	8	5·7—12·6	2·2—5	About 13 months	Cattewater. With these was 1 specimen 17·2 cm., probably 2 years old.
Apr. 30, 1891	5	5·0—6·0	2—2·4	,,	Plymouth Sound.
May 10, 1889	18	4·7—9·1	1·8—3·6	About 14 months	Cattewater.
May 8	2	7·9	3·1	,,	Cawsand Bay.
May 6, 1889	2	7·9	3·1	,,	Whitsand Bay.
Apr. 19, 1891	3	11·5—13·5	4·5—5·3	About 1 year	Large trawl, E. of Eddystone. Unripe males.
,,	6	14·4—18·3	5·7—7·2	Probably 2 years	Ripe Males.
,,	2	17·0—18·8	6·7, 7·4	,,	Females, 1 ripe, 1 nearly so.
Aug. 20, 1891	25	11·6—14	4·7—5·5	Probably 1 year and 5 months	Trawler, 5 miles S. of Eddystone
,,	22	14—16	5·5—6·3		
,,	30	16—18	6·3—7·1		
,,	36	18—20	7·1—7·9		
,,	5	20—22	7·9—8·7	Probably 2 years and 5 months	,, ,,
,,	2	22—24	8·7—9·5		
Dec. 10, 1889	5	14—18·5	5·5—7·3	1 year 9 months	Cattewater. Weight of the largest 2 oz. 6 drms.
Sept. 18, 1891	49	12·5—19·	4·9—7·5	1 year 6 mos.	From 2 trawlers working 5 to 8 miles S. of Eddystone.
,,	48	19—26	7·5—10·2	2 years 6 mos.	

According to Dr. Fulton the smallest ripe dab was $5\frac{1}{2}$ inches long, and the maximum specimen observed 14 inches long. The smallest ripe specimen seen by me was a male 5·7 inches in length; the smallest ripe female I have seen was 6·7 inches. The dab spawns in March and April, and in reckoning the ages in the above table I have counted from the month of March. It is certain that the ages given in the above table up to the entry for May 6th, 1889, are correct, and we see, from the sizes of those taken in the summer and autumn, the growth of the fish spawned the same year, while those taken between Christmas and May must be derived from the brood of the previous year, even the smallest taken in May, 1·8 inches, being too large to be attributed to the spawning of the same spring. Thus we find that a dab just over a year old may be as small as 1·8 inches in length; a conclusion not surprising in view of the fact that some of the flounders reared in captivity were only 1·6 inches at the same age. The maximum growth exhibited by this species in a year is more difficult to determine, but considering the case of the flounder we need have no doubt that the specimens 5 inches long, taken on April 3rd, were only just over a year old. Some specimens may very likely reach a greater size than this in the same time. The maximum observed in the flounder was $7\frac{1}{2}$ inches, and as the adult flounder is 2 inches longer than the adult dab, we may provisionally conclude that $5\frac{1}{2}$ inches is about the maximum length reached by a dab in one year. Thus we see that the minimum size, compatible with reproduction, may be reached or slightly surpassed at the end of the first year, but it is certain that the great majority of dabs at one year old are below that size. And it is not certain that those which are large enough to breed at the end of one year, do actually breed then. On the other hand the great majority of even the smallest ripe specimens are of a size that in all probability is not reached by any individuals in less than two years.

If we examine the entries of specimens obtained from the professional trawlers, we get some interesting results. In the first place we find that the smallest specimens captured are about $4\frac{1}{2}$ inches long. The breadth corresponding to this length is little over $1\frac{1}{2}$ inches. The meshes of the great beam-trawl, as used at Plymouth, are 4 inches square at the mouth, diminishing to $1\frac{1}{2}$ inches square at the cod end. Thus there is a close correspondence between the size of the mesh at the cod end and the smallest fish caught.

We may roughly estimate the growth of the dab in successive years as follows:

1st year . . . . 2 to 6 inches.
2nd „ . . . . . . 5 to 8 „
3rd „ . . . . . . 7 to 10 „
Maximum length . . . . 14 „

Distribution.—The above records show that although the young dabs under one year old, and 6 inches in length, are common everywhere in shallow water, penetrating even to the estuaries such as the Cattewater, where the greatest depths is only 3 fathoms, they are also taken out near the Eddystone at a depth of about 30 fathoms. In the latter region I took two specimens ·6 and ·7 inches long in July. These were taken in a shrimp trawl lined with mosquito-netting, having a mesh of about ¼ inch. The professional trawlers do not, however, catch specimens of the first year, because their mesh is too large. These conclusions as to the distribution are in complete agreement with those of Dr. Fulton.

Pleuronectes microcephalus, the Lemon Sole, or Merry Sole.

Date.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
Nov. 4, 1890	4	15·5—17·5	6·1—6·9	1 year 5 months	Firth of Forth; sent me by Dr. Fulton.
Aug. 20, 1891	5	16·8—20·1	6·6—7·9	1 year 4 months	4 or 5 miles S. of Eddystone, from professional trawler.
April 19, 1891	5	16·3—23·6	6·4—9·3	2 years	East of Eddystone, professional trawler. All ripe males.

The above data are all I have hitherto been able to collect concerning this species. The lemon sole spawns in May and June off the Firth of Forth, and in April and May off Plymouth. It is manifestly impossible that the young should reach a length of over 6 inches between May and November, since the adult lemon sole is but little larger than the adult flounder, and its growth not likely to be more rapid. Therefore the specimens taken in the Firth of Forth in November, and at Plymouth in August, are probably in their second year. As to the age of those taken in April, they might have reached the size of 6 inches in a year, but could scarcely have reached 9·3 inches in that time. If the lemon sole can become mature in one year some of these may have been one year old, and the larger ones two years.

It is noticeable that lemon soles only 6·4 inches long are sexually mature at Plymouth, while the smallest observed by Dr. Fulton to be ripe were 8½ inches long.

Hitherto, lemon soles, less than one year old, have not been obtained by me either in shallow or in deep water. Dr. Fulton obtained three specimens 2 inches in length in March and May, in about 20 fathoms. This shows that the growth is not more rapid than that of the flounder, since these specimens were ten to twelve months old.

Solea vulgaris, the Sole.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
May 15, 1889	15	1·2—1·5	0·5—0·6	About 1 month	Mavagissey Harbour, between tide-marks.
„ 10, 1889	3	16·8—19·5	6·6—7·7	1 year	Cattewater, taken in shrimp trawl.
„ 9, 1889	1	17·6	6·9	„	Under Citadel, shrimp trawl
June 17, 1889	1	19·8	7·8	1 year and 2 or 3 months	Whitsand Bay, 3 to 5 fathoms.
July 27, 1889	4	13·1—19·7	5·2—7·8	1 year and 3 or 4 months	Malpas, Falmouth River.
Sept. 19, 1890	2	16·0, 16·2	6·3, 6·4	1 year and 6 mos.	Cattewater, seine.
April 19, 1891	1	24·0	9·5	2 years	Large trawl, E. of Eddystone.

Most of these data were given in my "Treatise on the Common Sole," but I have slightly modified my interpretation of them. The specimens taken in the Sound up to 19·7 cm. in length I formerly considered to be two years old, but my observations on the flounder in captivity show that some soles probably reach this length at the beginning of their second year.

Solea lascaris, the French Sole, or Sand Sole.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
Sept. 28, 1889	1	9·0	3·5	4 months	Whitsand Bay, about 5 fathoms.
March, 1890	1	5·0	2·0	10 months	Off Falmouth, collected by Mr. Vallentin.
June 17, 1889	3	17·2—19·2	6·8—7·6	1 year	Whitsand Bay, 5 to 7 fathoms.

This species is not common, and it is therefore difficult to get more than an occasional specimen; the size of the adult is about the same as that of the common sole, and the above estimated ages are based on comparison with that of my captive flounders.

Solea lutea, the Little Sole.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
June 25, 1890	1	5	2	1 year	Cawsand Bay, 3 to 5 fathoms, shrimp trawl.
Sept. 21, 1891	7	7·4—8·5	2·9—3·4	1 year 3 months	Cawsand Bay, shrimp trawl.
„ 8, 1891	1	11·5	4·5	2 years 3 months	S.W. of Rame Head, 20 fathoms.
„ 3, 1891	2	10·8, 11·6	4·3, 4·5	„	„ „
Nov. 26, 1889	1	11·9	4·7	2 years 5 months	Cawsand Bay.

According to Dr. Fulton, this species spawns when it is 3¾ inches long, a length which seems to me to be reached at the end of two years. The fish rarely exceeds 5 inches in length, and specimens nearly as large as this occur occasionally in the shallow water of Cawsand Bay. But the adults are more commonly found farther from shore at depths up to 30 fathoms.

Solea variegata, the Thickback.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
July 9, 1891	2	4·5, 4·6	1·8	3 months	2 miles N. of Eddystone. Trawl of mosquito-netting.
Sept. 8, 1891	1	12·7	5	1 year and 5 months	Off Whitsand Bay, 20 fathoms.
Dec. 9, 1889	1	10·1	4	1 year and 8 months	Near Eddystone, from trawler.
Aug. 20, 1891	2	14·5, 15·2	5·7, 6·3	2 years and 4 months	5 miles S. of Eddystone, from trawler.

As this is a small species the maximum length observed by me being 21.5 cm., or 8½ inches, its growth is probably proportional; the spawning takes place in April and May. It will be observed that the only specimens under 2 inches long were obtained in deep water six miles from land.

I will take this opportunity of recording some observations I made on the relations of the sexes to one another in size and number in this species. On April 19th, 1889, on board a Plymouth trawling smack, I examined a large number of thickbacks taken in two or three hauls of the trawl. The result was as follows :

Number of males 34.—Largest measured 19·2 cm. long. Middle-sized specimen 17·0 cm.

Number of females 179.—Largest measured 21·5 cm. long. Middle-sized specimen 19·3 cm.

Thus the females in this species are both larger and more numerous than the males, as was found to be the case by Dr. Fulton in many other species of flat fishes. The proportion between the sexes is 526 females to 100 males, or one male to five females nearly. The ratio of females to males is even higher than this, according to Dr. Fulton, in the long rough dab, *Hippoglossoides limandoides.*

Rhombus maximus, the Turbot.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
Aug., year ?	6	2·4—3·8	·95—1·5	About 1 month	Collected at surface in Mevagissey Harbour by Mr. Dunn.
Aug. 11, 1888	1	3·7	1·45	„	At surface in Plymouth Sound.
Sept. 1, 1891	3	1·5—2	·6—·8	About 3 weeks	Surface at wharf, Cattewater.
Sept. 4, 1891	9	1·5—2·5	·6—1·0	3 weeks to 1 month	Surface at West Hoe Pier, Plymouth Sound.
Sept. 8, 1891	1	2·5	1·0	About 1 month	Tow-net surface, S.W. of Mewstone, about 4 miles from Plymouth Breakwater.
June 17, 1889	3	23—34	9—12	11 months	Whitsand Bay, 3 to 5 fathoms.

It will be seen from the above that the young turbot in process of metamorphosis, and swimming horizontally at the surface, occur at Plymouth and the neighbourhood in August and the beginning of September, while the brill at the same stage occur in May and June. It is thus evident that the turbot spawns later than the brill. I have estimated the age of these specimens about an inch long at one month, though they may be a little more. The spawning period, therefore, occurs in June and July. Wenckebach, in Holland, found turbot ripe in July.

I have no stages between the pelagic stage just mentioned and the small turbot, of 9 to 12 inches, obtained in Whitsand Bay in June, 1889. This year, although I have several times trawled in Whitsand Bay, I have obtained no specimens of this species. At present I see no reason to suppose that the specimens of 9 to 12 inches were more than one year old; it is certain that they were not less, as the spawning takes place in June and July. The largest turbot recorded by Dr. Fulton was 28 inches long, and the smallest mature was 18 inches long. It is probable that a turbot 2 feet in length is at least four years old.

Rhombus lævis, the Brill.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
June 4, 1889	1	2·5	1·0	About 1 month	Surface off Lambhay Point, at entrance of Cattewater.
May 21, 1890	20	2·2—2·5	·85—1·0	3 wks. to 1 month	Sutton Pool, Plymouth.
June 11, 1890	14	,,	,,	,,	Ditto.
Sept. 30, 1890	1	18·5	7·2	1 year 4 months	Seine at Cremyll, Plymouth Sound.
Specimens reared in the Aquarium.					
May 21, 1890 } June 11, 1890 }	34	2·2—2·5	·85—1·0	3 wks. to 1 month	
Oct. 4, 1890	1	8·5	3·45	6 months	
,, 18, 1890	4	7·0—9·8	2·8—3·9	,,	
April 3, 1891	2	8·4—8·8	3·3—3·7	11—12 months	

The young brill occur floating at the surface in May and June, at which stage they are in process of metamorphosis, swimming in a slanting or horizontal position, and provided with a large air bladder. They cannot well be less than three weeks old at this stage, and the eggs must, therefore, be shed in April and May. Raffaele believes that at Naples the eggs are shed in February and March, and one would naturally expect the spawning period to be earlier in the Mediterranean.

According to the results observed in the specimens reared in captivity, the growth would seem to be very slow, not exceeding 4 inches in twelve months; but it will be seen from the table that this length was almost reached in six months, so that scarcely any increase in size took place after the first six months. It is probable, therefore, that the growth of my captive specimens was abnormally checked. In nature, these fish feed chiefly on living fish of other species, and I was unable to provide such food for my captive specimens, but fed them on marine worms. On the other hand, I think it unlikely that the specimen obtained in the sea September 30th, 1890, could have reached its length of 7·2 inches in five months, and, therefore, I have considered it to be more than one year old. The adult brill is from 18 inches to 2 feet long, the latter being the maximum length observed. If 7 to 8 inches is the average growth in one year, the growth of the brill would appear to be slower in proportion to its size than that of the flounder, and it would probably take four years to reach a length of 18 inches. Additional data are needed, but I have found it difficult to find specimens of two to twelve months old in the sea. The species is much less common than the plaice, flounder, or dab, and even the adults are only taken sparingly by the professional trawlers.

Arnoglossus laterna, the Scald-back.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
Oct. 3, 1889	2	2·8—3·4	1·1—1·4	4 or 5 months	Cawsand Bay, shrimp trawl.
Feb. 9, 1888	11	4·5—6·3	1·8—2·5	8 or 9 months	Cawsand Bay, 3 to 5 fathoms.
May 8, 1889	1	4·7	1·9	11 months	Cawsand Bay.
Feb. 9, 1888	5	9·3—11·5	3·7—4·4	1 year and 8 months	Cawsand Bay.
Sept. 4, 1890	8	8·5—12	3·4—4·7	1 year and 3 months	W. of Rame Head, 20 fathoms.
Sept. 3, 1891	19	8·8—13·2	3·5—5·2	„	3 miles N. of Eddystone, 25 to 30 fathoms.
„	35	8·8—13·8	3·5—5·4	„	Off Plymouth Sound, 20 fathoms.
Sept. 8, 1891	77	7·8—12·6	3·1—5	„	Off Mewstone and Whitsand Bay, 23 to 27 fathoms.
Sept. 12, 1891	13	8—12	3·15—4·7	„	8 to 10 miles S. of Eddystone, 36 to 38 fathoms.
Dec., 1889	43	14·7—20·4	5·8—8	Over 2 years, adult and sexually mature	10 to 20 miles from shore off Plymouth, from professional trawler.

I do not know exactly the spawning period of this species, but believe it occurs in summer, in May and June; the ages in the above table have been reckoned from June. I have only obtained the very small specimens, less than one year old, in Cawsand Bay, at 3 to 5 fathoms depth, in the small shrimp trawl. In September of the current year I obtained large numbers of the species, 7 to 14 cm. long, in an otter trawl, both inside and outside the Eddystone, at depths varying from 20 to 38 fathoms. I think it is impossible that these should be derived from this year's spawning, since small specimens, less than 4 cm. long, and evidently a few months old, were taken in Cawsand Bay in October. It follows, therefore, that the specimens taken in September, 7 to 14 cm. long, are in their second year. The adult condition in this species is distinctly marked in the male sex by the sudden elongation of the anterior dorsal fin-rays which occurs when sexual maturity is reached, and which I have observed only in specimens over 14 cm. in length. The largest specimens I have seen were 20·4 cm. long. I have only obtained the adults from the deep sea trawlers, and they were taken at some distance from the coast. There seems, therefore, to be a regular distribution of the different stages, those of the first year occurring in shallow sandy bays, of 3 to 5 fathoms in depth; those of the second year occurring from shallow water to a depth of 36 fathoms, but being especially abundant between 20 and 30 fathoms;

while the adults occur principally beyond the 30 fathoms line. The adult condition and sexual maturity is not reached till the end of the second year.

Gadus merlangus, the Whiting.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
June 13, 1889	2	5·7	2·2	3 or 4 months	Whitsand Bay, 3 to 5 fathoms; small meshed trawl.
July 16, 1891	13	5·4—9·0	2·1—3·5	4 or 5 months	2 miles S. of Eddystone; large tow net, 8 feet by 6 ft. at mouth; 11 specimens at 15 fathoms from surface, 2 at 6 fathoms. These were all the whiting caught.

The second entry shows that the young whiting, from eggs spawned the previous spring, occur not only in shallow bays close to the bottom, but also at some distance from land in mid-water. The whiting at Plymouth spawns in February and March. I think there can be no doubt that these whiting were under six months old, and were hatched in the previous March, and that they were not in their second year. Dr. Fulton describes the occurrence of a great shoal of young whitings, from 2 to 5 inches in length, in September; these young fish were so numerous that over 3000 were taken at a single haul of an 18 foot beam-trawl. Dr. Fulton seems unable to account for the origin of this shoal, apparently rejecting the obvious idea that the fish comprising it were hatched the previous spring. He says the whiting spawns in March, April, May, and June, and that a pelagic specimen, 1 inch long, has been captured by the tow-net in September, by Prof. McIntosh. Now, according to my own experience, the whiting spawns in the Firth of Forth and neighbouring sea, principally in April, and young fish hatched in April cannot be only 1 inch long in September, when five months old. I think the various observations I have here brought together with regard to other species show, conclusively, that the whiting mentioned by Dr. Fulton, from 2 to 5 inches in length in September, were hatched in the preceding April and May.

Gadus pollachius, the Pollack.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
Apr. 3, 1890	22	2—2·4	·8—·95	3 to 6 weeks	Taken with hand-net in Mevagissey Harbour.
Oct. 2, 1890	10	9·7—11·2	3·8—4·4	7 months	Taken in cheesecloth trawl, Cawsand Bay, 3 to 5 fathoms.
Dec. 4, 1889	4	9·3—11·8	3·7—4·7	9 months	Taken from the dry dock at Millbay when the dock was emptied.

I have not myself made any observations on the spawning of the pollack, but there can be no doubt that it spawns early in the year, in February and March. It may also be assumed that the ova are pelagic and buoyant. The few data given in the table are not sufficient to show the rate of growth with certainty, but I think they may be trusted as far as they go. It may be inferred that 7 inches is about the maximum growth for one year. The pollack caught in Plymouth Sound in June and July are 12 to 15 inches in length. These are, I believe, over two years old. The fish grows to more than 2 feet in length. I have no evidence to show whether it begins to breed when only one year old or not. The pollack is a coast fish, and its young seem always to be found in shallow water, in bays and inlets, and in the neighbourhood of rocks and piers. It is seldom, though occasionally, taken in the trawl, as it feeds mostly in mid-water, not on the bottom, and usually occurs in the neighbourhood of rocks and weeds.

Gadus luscus, the Pout or Bib.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
June 17, 1889	11	6·4—7·7	2·5—3·0	3 months	Whitsand Bay, 3 to 5 fathoms; small-meshed trawl at night.
Sept. 5, 1890	1	11·7	4·6	6 months	Cawsand Bay; shrimp trawl.
Oct. 2, 1890	2	10·7—13·0	4·2—5·1	7 months	Ditto.
June 17, 1889	1	12·5	4·9	1 year 2 months	Whitsand Bay; small-meshed trawl.

This species grows to about 1 foot in length, and we may judge from the last entry in the table that its size at the end of the first year is 5 to 6 inches. In June it is 2 to 3 inches in length, and at

this stage I have taken it, though sparingly, in shallow water in Whitsand Bay. Specimens in their second summer, just over one year old, are abundant in June and July in Plymouth Sound and elsewhere along the coast in shallow water, and are taken in numbers by hook and line. Specimens of the same age and about 6 inches long are also taken by the deep-sea trawlers in depths up to 30 fathoms. I have as yet, however, made only the above records.

Gadus minutus, the Poor Cod.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
May 28, 1890	12	2·8—4·3	1·1—1·7	8—12 weeks	Shrimp trawl, in Catwater.
June 17, 1889	218	4·2—7·2	1·6—2·9	About 3 months	Small-meshed trawl, in Whitsand Bay, 5 to 7 fathoms, at night.
July 9, 1891	6	11·5—16·2	4·5—6·4	1 year 3 months	Taken in shrimp trawl, 2 miles north of Eddystone, 27 fathoms.
April 19, 1891	7	14·3—19·0	5·6—7·5	2 years	The smallest specimens taken by a professional trawler to the east of Eddystone, 30 fathoms.
June 17, 1889	2	13·7—15·0	5·4—5·8	1 year 2 months	Small meshed trawl, Whitsand Bay, 5 to 7 fathoms, at night.
	1	20·0	7·8	2 years 2 months	

The observations on this species are very inadequate, but they supply some definite facts. The occurrence of more than two hundred specimens less than 3 inches long in Whitsand Bay, undoubtedly from ova shed the preceding spring, shows that the young frequent shallow water and sandy ground. It is also clear that the specimens, 4·5 to 6·4 inches, obtained on July 9th, near the Eddystone, were in their second year. I have not ascertained at what size the species begins to breed. But specimens of 4 to 6 inches, and just over a year old, were caught in the Sound and placed in our tanks in the summer of 1889, and were breeding there in March, 1890. I am pretty sure this was their first time of breeding. I am not quite sure as to the size attained in two years, but as the rate of growth in length decreases gradually, I think those of April 19th, 1891, in the table, must have been two years old. The poor cod never exceeds 9 inches in length.

Zeus faber, the Dory.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
Oct. 3, 1889	1	4·3	1·7	About 3 months	Cawsand Bay, 3 to 5 fathoms; shrimp trawl.
June 3, 1889	3	12·5—14·1	4·9—5·5	11 months	3 miles from Rame Head, 20 fathoms; small-meshed trawl.
Aug. 20, 1891	7	13·5—15·6	5·3—6·1	1 year and 1 month	5 miles S. of Eddystone; professional trawler.
Sept. 8, 1891	2	17·2, 17·5	6·8, 6·9	1 year and 2 months	Whitsand Bay, 5 fathoms; otter trawl.
"	1	16·6	6·5	"	S.W. of Rame Head, 20 fathoms; otter trawl.
Sept. 18, 1891	5	14—18·5	5·5—7·3	"	5 to 8 miles S. of Eddystone; professional trawler.
Apr. 21, 1891	1	24·5	9·6	1 year and 10 months	S.E. of Eddystone, 35 fathoms; professional trawler.
Sept. 3, 1891	1	28·2	11·1	2 years and 2 months	S. of Rame Head, 25 fathoms; otter trawl.

Although the above table includes but a small number of specimens, I believe that it represents with considerable certainty the growth of the dory. I do not know exactly when the dory spawns, but I have examined the adults in spring and found the ovaries ripening, and in autumn have found them shotten, so that I conclude the spawning takes place about June and July. In the table I have reckoned the ages from July. It will be seen that specimens from 5 to a little over 7 inches in length are fairly common in August and September, and since young specimens of 1 to 2 inches in length occur in autumn, it is evident that the former are just over one year old, while the latter are derived from eggs shed in the preceding summer. The last specimen in the table is, I think, too large to be only one year old, and I therefore judge it to be in its third year. The largest dory mentioned by Day was 22½ inches long, but the usual size is from 15 to 18 inches, which is probably not reached in less than three years.

Motella mustela, the Five-bearded Rockling.

In this Journal, vol. i, p. 372, I mentioned some specimens of this species kept in the Aquarium from May to August, 1890. All except one of these were placed in a large tank and have not been seen again, but the remaining specimen was measured alive on May 19th, 1891, when just over a year old, and found to be 13·0 cm., or 5·1 inches long. Measured again on September 21st, it

was exactly the same length. In the tank with it were several vigorous flounders, and probably this was the reason that it had not grown, the flounders having seized all the food put in the tank. But numbers of this species, 5 to 7 inches in length, occur under rocks, between tide-marks, in summer, which are obviously at the commencement of their second year. This species reaches 18 in. in length, and does not change colour when adult. My young specimen, like the adult, is a dark rich brown on the sides, black on the back, white on the ventral surface.

Motella tricirrata, the Three-bearded Rockling.

On June 20th of the present year I went out for a fishing trip in a mackerel boat, and when we got as far as the Mewstone it fell dead calm, and remained so for some hours. The surface of the sea was covered with great quantities of *Noctiluca miliaris*, here and there collected in patches and streaks into a thick scum of a salmon-pink colour. Darting about at the surface were numerous small active fishes, of which I secured a great number, and found on examining them ashore that they were the young of *Motella tricirrata*, the three-bearded rockling. These young fish were swimming at the very surface of the water, causing it to ripple by their motion. Fishermen at Plymouth call all such young fish "britt," not distinguishing one species from another. The older naturalists described this young form as a distinct species, and Couch calls it the mackerel-midge.

Among my specimens there are three stages to be distinguished, which pass gradually into one another. The oldest stage is from 2·5 to 3·2 cm. long (1 to 1·3 inch), and is closely similar to the adult, except that the sides are brilliantly silvery, which is not the case in the adult. In this stage the fins are all similar to those of the adult, the pelvic reaching only half way to the anus. The youngest stage is under 1 cm. in length, and the skin is almost transparent, the silvery opacity commencing to develop in the largest specimens. There are pigment cells, especially on the back. The fin-rays have only recently begun to develop and are not complete at their distal ends; the anterior dorsal fin is not visible, but the principal peculiarity is the pelvic fins, which are comparatively long, extending beyond the anus, and having a dense black colour over their outer halves. The second stage is intermediate between these in all respects: it is from 1 to 2·5 cm. in length, and in the different specimens in this stage can be traced the development of the silvery layer in the skin, and of the anterior dorsal fin, and the gradual reduction of the pelvic fin. A specimen of the young

Motella in the second of the stages above mentioned, is described and figured in my paper in this Journal, vol. i, p. 47.

Caranx trachurus—the Scad, or Horse-mackerel.

This is a pelagic species frequently taken in mackerel nets. Its young are also pelagic, and I have taken them in the tow-net in August and September. In August, 1888, one 5·4 cm. (2·1 inches) was taken three or four miles off Loae. On September 8th this year I took two, 2·4 and 3·5 cm. long, to the south-west of the Mewstone; and on September 12th, one 2·5 cm. long, about five miles south of the Mewstone.

Comparisons and Conclusions.

1. *Flat fishes.*—If we consider first the species of the genus *Pleuronectes* alone we find some curious and interesting differences. We find that the flounder and plaice when immature, that is under 7 and 9 inches respectively in length, and less than two years old, are almost entirely absent beyond the 20 fathom line. The young of these two species are abundant in the estuaries of Cattewater and the Hamoaze. In June, 1889, I found plaice 1 to 3 inches long, spawned the previous spring, in abundance in Whitsand Bay, which is not an inlet, but a bay open to the sea; but during the present summer, I have trawled there several times in July and September and found no young plaice at all. On the other hand, the dab (*Pl. limanda*), even under one inch in length and only three months old, occurs, though not abundantly, near the 30 fathom line, a little inside the Eddystone. It is much more abundant at this age in Cawsand and Whitsand Bays, at depths of 3 to 7 fathoms. Up to 5 inches in length it is common in the Cattewater, where also larger specimens are not uncommon. The trawlers working off Plymouth between 20 and 40 fathoms bring up numbers of small flat fishes, but, with very few exceptions, these are all dabs or scald-backs, *Arnoglossus laterna*. The smallest dabs I have obtained from the trawlers were 4½ inches long, a length which may be reached by some individuals at one year of age. Thus, although specimens of less size and age than this are not uncommon at depths of 10 to 30 or 40 fathoms, the great beam trawl does not catch them because its meshes are too large. I have not kept records of the small scald-backs brought up by the great beam trawl, though when studying other subjects on board trawlers I have seen numbers of them brought up. During the present summer, however, when fishing

with an otter-trawl myself, on purpose to obtain young fish, I have obtained large numbers of this species from 3 to 5 inches in length. I find that specimens of this size are between one and two years in age, are not sexually mature, and are distributed at all depths from 3 to 40 fathoms.

Pleuronectes microcephalus, the merry-sole, is the only other species of the genus usually met with near Plymouth. There is no doubt that the young, under 6 inches long, and less than one year old, are entirely absent from shallow water, under 10 fathoms, and from inlets and estuaries. No destruction of the young of this species can be effected by shrimp, or seine, or bag-net fishing in territorial waters. As far as my observations go, the professional deep-sea trawler does not capture the young of this species under 6 inches, but on this point I have collected very few data up to the present time. It is, however, certain that the species belongs to rather deep water ; it is scarce at less than 30 fathoms, and abundant at greater depths. I have not yet obtained any specimens under 6 inches long, but Dr. Fulton obtained three specimens, 2 inches long, at about 20 fathoms. I have not met with any such specimens in my numerous hauls with small-meshed trawls this summer inside the Eddystone. I am inclined to think that most of the young of this species, when they go to the bottom, remain in deep water beyond the 30 fathom line.

I have not yet found young soles between ½ inch and 6 inches in length, although I have specially searched for them at various depths up to 35 fathoms. My evidence concerning this species is similar to that concerning the brill and turbot ; in all three cases I have found the very young forms only a few weeks old close to the shore in harbours and inlets, and have taken other specimens much larger and about one year old in territorial waters within the 10 fathom line.

With regard to the age of sexual maturity, I have proved that a large number of individuals do not reach the minimum size of mature specimens at the end of one year, and that it is quite probable that all flat fishes normally breed for the first time when two years old.

2. *Other species.*—It will be seen that the young of all the species of Gadus mentioned above, namely the whiting, pollack, pout, and poor-cod, for the first six months of their existence are found close to the shore, the fry of the pollack and poor-cod seeking harbours and estuaries, and being seen in numbers swimming about near piers and wharves. When about one year old, these kinds of fish are found in abundance at depths of 5 to 30 or more fathoms. The pollack haunts rocky shores all its life, and only very large

specimens, 12 inches to 2 feet long, are occasionally taken in the great trawls, but of the other species many one-year-old individuals are destroyed by them. It is remarkable also how commonly one-year-old dorys are taken in the deep-sea trawls.

Practical Considerations.

A great deal of work remains to be done before we obtain an adequate knowledge of the life-histories of our valuable sea fishes. I hope to continue my own observations in various directions, and in future to add largely to the data recorded above. But in the meantime the question of the harm done to our sea fisheries by the destruction of under-sized or immature fish is constantly being agitated, and cannot be too carefully considered. Our national statistics show that our best sea fish are getting scarcer. It seems at first sight the irony of fate that the finest fish such as sole, turbot, brill, and dory should be scarce, while inferior kinds such as dabs are plentiful, and worthless kinds such as scald-fish and dog-fish are still more abundant. The case of the sole is difficult to explain. It feeds on worms chiefly as do the plaice and flounder, yet it is by no means so plentiful as the plaice. One might be tempted to maintain that the sole is really no better intrinsically than the plaice, but only valued more because it is dearer. But a moment's consideration of the difference between the flesh of the two is enough to dispel such an idea. In the case of the turbot, brill, and dory, however, there is a reason why they are relatively scarce. These fishes, compared with many other kinds, are as the Carnivora to the Herbivora on land. They feed exclusively on other fishes. They are fishes of prey, and must, therefore, as in the case of other Carnivora, exist in smaller numbers than the fish they prey upon. Perhaps some day we shall also be able to understand why the sole is less abundant than the plaice.

But the practical question is how to prevent the decrease in the supply of fishes whatever their natural numerical proportions to one another, and one obvious precaution is to prevent as far as possible the destruction of the young. I will, therefore, here indicate the bearings which my observations at Plymouth have upon this practical question. Dr. Fulton, throughout the whole of his inquiry, has interpreted the term immature fish as meaning a fish not yet capable of reproduction. The fishermen of the east coast, who have been so strongly moved on the subject of immature fish, knew nothing and cared nothing about the size at which a fish of a certain kind began to breed. What they were thinking of was the fact that if all the small fish were caught there were none left to grow large, and con-

sequently, as the large fish were more valuable per pound, their work became less remunerative. Dr. Fulton evidently thinks that a fish ought not to be destroyed before it has spawned at least once, and that if it is sexually mature there can be no harm in capturing it. Thus he would only preserve lemon soles (*Pl. microcephalus*) up to 8 inches, while the fishermen wanted to place the limit at 12 inches. Theoretically I am more in agreement with the fishermen on this point than with Dr. Fulton. It seems to me that the mere fact that a fish at a certain small size is capable of breeding, is not a reason for capturing it if its full-grown size is very much larger. Salmon parr in our rivers are sexually mature, at least the males are when only a few inches long, but their capture is prohibited nevertheless. If it were possible to limit the capture of each sea fish to those above a certain size, I think the limit should be determined by the size of the full-grown fish, and not by the size at which it begins to breed. At the same time the limit should not be fixed below the minimum size of sexually mature individuals.

However, it is not possible to fix a different limit of size for each species of fish captured by the deep-sea trawlers. The only differences in the smallest sizes caught with a given mesh will be due either to differences in the distribution of the young of the several species, or to differences in the shape of the fish. Thus a sole, 10 inches long, could escape through a mesh say 3 inches square, while a turbot, brill, or dory of the same length could not, because the latter three fish are so much broader than a sole in proportion to their length. All that is practically feasible in the case of the deep-sea trawl is to increase the size of the mesh so as to allow more small fish of whatever kind to escape.

The destruction of under-sized fish in the neighbourhood of Plymouth may be described under two heads : (1), that which is due to the deep-sea trawlers; (2), that which is due to inshore fishing. The deep-sea trawlers capture large numbers of under-sized soles, lemon-soles, dorys, dabs, pout, whiting, and gurnard. The dabs are, perhaps, of no great importance, but the young pout and poor-cod (*G. luscus* and *G. minutus*) form an important part of the food of the turbot, as I know from examination of the stomachs of the latter. None of these young fish are of much value in the market. Some of them are sold separately, and the proceeds are by custom allowed to the crew as perquisites. If the mesh of the trawl were enlarged these small fish would not be caught. The mesh at the cod-end is now $1\frac{1}{2}$ inches square, and at the mouth, 4 inches. I believe that the mesh ought to be not less than 3 inches square at the cod-end, and I think that this change would have the additional advantage of allowing much of the useless material known here as

"scruff" to escape. However, together with the scruff, on certain grounds large quantities of so-called queens (*Pecten opercularis*) are taken, and these are eaten to a considerable extent by the poorer people. These would probably not be caught by a 3-inch mesh, and their loss would have to be considered. I do not believe that it would be of much use to return to the sea the under-sized fish taken in the deep-sea trawl, leaving the mesh unaltered. It is true that most of the small fish are alive when brought on deck; they flap about and move when touched, but by the pressure of the great mass that the trawl contains, the violent concussions of this mass against the sides and bulwarks of the vessel, the sudden fall of the mass on deck when the end of the trawl is opened, and the trampling of the heavy boots of the crew as they handle the gear, the majority of the small fish are so much injured, especially in rough weather, that a great many of them would die sooner or later if thrown overboard.

The inshore fishing which destroys young fish consists principally of shrimp-trawling, fishing with small fish-trawls, and ground-seining. The shrimp trawls in Plymouth Sound take numerous small soles which ought not to be taken. This would be prevented if it were made illegal to keep them, because these fish are not in the least injured when brought up in the trawl. The ground-seines destroy large numbers of small plaice and flounders in the Cattewater and Hamoaze, but I have been informed by Mr. Henry Clark, who holds exclusive fishing rights in the upper part of the Cattewater, that fish of all kinds have grown very scarce there in recent years, probably, in his opinion, in consequence of the pollution of the estuary by manure and china-clay refuse. The ground-seines are used chiefly for the purpose of catching mullet and bass, and there would be no difficulty in compelling the fishermen who use them to return small flat fishes to the water, for these fishes are not injured in the process of capture by this method. The small fish trawls are worked by small sailing-boats in Whitsand Bay and Bigbury Bay. Their most valuable produce consists of small turbot and brill, and they take more under-sized fish of all kinds in proportion to the total catch than the deep-sea trawls. I think this kind of fishing should be prohibited altogether, at least in certain areas. The inshore bays should be strictly preserved as nurseries for young plaice, dorys, turbot, and other fish, which are at present captured in them. The Cornwall County Council has passed a bye-law prohibiting steam trawling in territorial waters within its district. It seems to me that this is a perfectly justifiable measure in relation to what it does, but not in relation to what it leaves undone. Small steamers, and tugs at times, when they are not employed in their

proper work, are on many parts of the coast used for trawling in bays and inshore waters, and are very destructive on account of the ease with which they are handled. It is a good thing, therefore, that this kind of fishing should be prohibited, but it is inconsistent and unreasonable to allow sailing boats to do that which steamers are prohibited from doing.

On some Ascidians from the Isle of Wight:

A Study in Variation and Nomenclature.

By

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With Plates VI and VII.

Although the Isle of Wight has been a favourite haunt of the geologist and the palæontologist, references to its present marine fauna are exceedingly rare in zoological literature. Early in May of the present year, however, I had an opportunity, at the suggestion and through the kind hospitality of my friend Mr. Poulton, of examining the littoral fauna of the eastern shores of the island, and of making a considerable collection of zoological specimens. A list of the species which I obtained will be published as soon as I have had time to complete the examination of them; but several of the Ascidians throw so much light upon the brief and obscure descriptions of certain species, that I believe it will be serviceable to give a full account of them without further delay, especially since the pressure of other work may prevent an early appearance of the complete list.

I.

Ascidia mollis, *Alder and Hancock.*

Ascidia mollis, *Hancock.* Ann. Mag. Nat. Hist. (iv), vol. vi, 1870, pp. 358, 359.

I found eleven individuals of this species attached to rocks in the Zostera bed off Nodes Point, St. Helen's, at extreme low water, May 7th.

The short account of *A. mollis* given by Hancock is admirable as regards the description of the external features, but is insufficient in some points of internal structure. I am glad, therefore, to have an opportunity of re-describing this Ascidian. It appears to be a comparatively rare species, and I am not aware that it has been

hitherto recorded from any other locality than the coast of Connemara, in the West of Ireland.

The *body* is ovate in form, thick, lobate, attached generally by the posterior half, sometimes by a larger area of the left side. When living, it is invariably of a rosy-flesh colour; and this colour, upon close examination, is seen to be due to a number of crimson dots (the culs-de-sac of the test-vessels) profusely scattered in the substance of the test.

The dimensions of the largest individual (Pl. VI, fig. 1) are as follows:

Maximum length (antero-posterior)	. .	$1\frac{1}{16}$ inch
,, breadth (dorso-ventral)	. .	$\frac{3}{4}$,,
,, thickness (right to left)	. .	$\frac{3}{8}$,,

The oral and cloacal *apertures* are on the right side of the body; the oral is sub-terminal, the cloacal half-way down and near the dorsal edge; both are small and inconspicuous. The position of the cloacal aperture varies very little in these specimens; in a few it is slightly posterior to the middle dorso-ventral line, but never so much so as to be two-thirds of the way down. No *ocelli* were observed around the apertures.

The *test* is, in Hancock's words, "firm, thick, semi-transparent, smooth and soft to the touch, rather shining, obtusely lobed, of a rosy flesh-colour, showing minute punctures and veinings of crimson." In its thick, smooth, firm, and shining character, the test of this species resembles that of *Phallusia mammillata*, a resemblance further borne out by the lobes of its surface, although these are much flatter and less protuberant in *Ascidia mollis*, than in the latter species. In its softness, however, the test of this species is very unlike that of *P. mammillata*.

Hancock states that the "terminal extremities" of the blood-vessels of the test are "more inflated and globular in this than in any other species." I have a distinct recollection of their pyriform character in the living animal, but their appearance in specimens after preservation in alcohol is very different; and they are seen to be elongated and finger-shaped, rather than inflated and globular (Pl. VI, fig. 2).

When the test has been removed from the rest of the body, the oral and cloacal *siphons* are seen to be short (Pl. VI, fig. 3). The *musculature* is, as usual, almost confined to the right side of the body; the fibres are long and delicate. Round each of the siphons a number of delicate fibres form a complete sphincter.

On the left side, the course of the intestine is visible through the body-wall. The *stomach* is rounded in form and is situated at some little distance (about one-fifth of the total body-length) from

the posterior end of the body. The *intestine* is narrow and uniform; its first bend is well in front of the cloacal siphon, its anterior wall being on a level with the ganglion; the second bend of the intestine is behind the cloacal siphon, its posterior wall being on a level with the opening of the œsophagus into the pharynx; the rectum is directed obliquely forwards towards the cloaca.

Upon opening the pharynx from end to end, along the line of the endostyle, the remaining structures can be examined.

The *coronal tentacles* are forty or more in number. In an individual possessing forty tentacles, they were of three sizes and regularly arranged—ten long and slender primaries, ten intermediate secondaries, and twenty short tertiaries.

The *præbranchial zone* is studded with microscopic papillæ.

The aperture of the *dorsal tubercle* is crescentic in the smaller specimens, horse-shoe shaped in the individual represented in fig. 1, the horns not being incurved.

An *epipharyngeal groove* extends along one-third of the distance between the dorsal tubercle and the ganglion, which is situated half-way between the mouth and the cloacal aperture. The ganglion is small, three times as long as broad, and extends over three of the meshes of the pharyngeal wall, beginning at the fourteenth horizontal bar. The epipharyngeal groove becomes elevated towards it posterior end, and behind it commences the *dorsal lamina*, which is very narrow, strongly ribbed transversely, and pectinated at its margin. The ribs and teeth of the lamina correspond in number with the horizontal bars of the pharyngeal wall. Occasionally there are minute projections from the edge of the lamina which alternate with the teeth in position. The concave side of the lamina shows a series of weak ridges running towards its edge very obliquely from before backwards.

Branchial apparatus.—A portion of the inner face of the pharyngeal wall is shown on Pl. VI, fig. 4. The horizontal vessels form three complete series and a rudimentary growth. The primary vessels (*h. v.* 1), which give off branches* to the body-walls, are usually of greater diameter than those of the remaining series. Between each pair of primaries are situated one secondary vessel (*h. v.* 2), and two tertiary vessels (*h. v.* 3), at approximately equal distances.

Connecting ducts (*c. d.*) arise from all these vessels and support delicate internal longitudinal bars (*i. l. b.*) which are surmounted at the points of junction by moderately stout conical papillæ (*p.*) and at intermediate points by comparatively slender ones (*i. p.*). The

* The origin of these branches—the dermato-branchial connectives—is marked in some specimens by white spots upon the primary horizontal bars.

connecting ducts themselves are sub-triangular in shape when seen in profile. The horizontal and internal longitudinal vessels delimit meshes, which are sometimes almost twice as long as broad, and contain four or five stigmata each. The stigmata are elongated, with rounded ends; they are frequently double, and then consist of an anterior and a posterior portion of elliptical shape. The pharyngeal wall is minutely plicated in a longitudinal direction. The meshes almost invariably show some trace of a division into two equal portions by the formation of an incomplete quaternary series of horizontal vessels; the extent to which this process is carried out varies in different individuals and in different parts of the same pharynx. The process is interesting, and may be completely traced in fig. 4. A small projection arises from the internal face of an interstigmatic bar, at its middle point (see fig. 4, upper row, third mesh from the left), and is joined by a similar projection from the opposite wall of the stigma (see the mesh below). The concrescence of the two projections forms a horizontal bridge across the middle of the stigma. The formation of several such bridges across adjacent stigmata thus gives rise to a small horizontal vessel (see the mesh below), which may be said to form part of a quaternary series; these quaternary vessels (*h. v.* 4) may even form connections with the internal longitudinal bars beneath the intermediate papillæ (*i. p.*) of those structures. My figure represents the condition of the branchial apparatus in the individual shown in fig. 3; but in a somewhat larger individual (fig. 1) the intermediate or quaternary vessels are much more highly developed, and there is less difference between them and the other horizontal vessels. There is no pharyngo-cloacal slit.*

The *œsophagus* opens into the pharynx high up on its dorsal edge, halfway between the cloacal siphon and the posterior end of the body. In the largest specimen there are six primary horizontal bars between the œsophageal opening and the posterior end of the pharynx.

All my specimens are immature; in even the largest individual the development of the generative organs is still incomplete, and the ducts are very slender in form; while in smaller specimens the gonads are quite rudimentary.

In addition, however, to the specimens of which the above account has been given, I took another Ascidian which there is every reason to believe to be an adult individual of the same species, but which, from its exceptional shape, is at least an abnormal one, so that I have excluded it from the general description.

* See p. 132.

It is represented of the natural size on Pl. VI, figs. 5 *a* and 5 *b*, and deprived of the test, by fig. 6. The *body* is not compressed from side to side (right to left morphologically) like an ordinary Ascidian and like normal individuals of the same species, but dorso-ventrally; and thus it comes about that, although attached in the usual manner by its left side, its right side does not present a flattened surface, but is elevated so as to form a thickened longitudinal ridge of considerable height.

The dimensions are as follows:

Length (antero-posterior) . . .	2 inches.
Breadth (dorsal-ventral across the plane of attachment)	$\frac{5}{8}$,,
Thickness (morphological right to left) .	$\frac{7}{8}$,,

The breadth becomes considerably reduced towards the summit of the ridge which represents the right side of the body.

The *test* is very thick and presents all the characters of normal individuals of *Ascidia mollis*, except that it is much corrugated on that face of the body which contains the cloacal aperture (see fig. 5 *a*). The *oral aperture* is sub-terminal and on the same side as the cloacal aperture, which is slightly nearer the anterior than the posterior end of the body. The body is attached by almost the whole of the left side, which is deeply furrowed and irregularly pitted. The test is overgrown by extensive colonies of the Polyzoon *Cylindrœcium dilatatum*.

Upon removal of the test, the extent of the dorso-ventral compression is at once noticed. The *ganglion* and *cloacal siphon*, instead of occupying their usual position upon the apparent left of the body, are in the median line of the upper side; and the whole of the *viscera* appear to have suffered a similar rotation through 90 degrees. Strictly speaking, however, the viscera present exactly the same morphological relations to the rest of the body as in the normal individuals described above.

The *generative organs* are well developed, and the oviduct and vas deferens are remarkably dilated. The former contains numerous ripe ova, of small size; and the latter is filled with a mass of spermatozoa.

The only difference of any importance in the pharynx is the presence of a *pharyngo-cloacal slit*,* $\frac{1}{8}$ inch in length, in the usual position opposite the cloacal aperture.

The *præbranchial zone* is closely studded with minute papillæ.

The growth of the aperture of the *dorsal tubercle* has progressed still further; both horns are now curved inwards.

Epipharyngeal groove and *dorsal lamina* as in younger specimens,

* See p. 132.

but the lamina is a little deeper; the ribs are very strong and regular, the teeth rather short, very regular, without intermediate smaller ones; the concave side of the lamina as described above.

Behind the œsophageal aperture is a long smooth area (the "post-buccal raphé" of Roule), bounded on the left by a continuation of the dorsal lamina, and on the right by a series of terminal elevations of the horizontal membranes of that side, as in *A. mentula*.

Branchial apparatus.—This is much as in younger specimens, but the arrangement of horizontal bars into primaries and secondaries, &c., is less obvious, owing to the increase of the quaternary vessels which are in many parts of the pharynx completely formed. Rudimentary quaternaries are rare.

The papillæ at the junctions are bluntly conical; the intermediate papillæ are well developed and slenderly conical. The meshes are slightly longer than broad, except where new quaternaries are forming, when they are twice as long. There are from five to seven stigmata in a mesh.

Between this Ascidian and the immature specimens of *A. mollis* described above, the only points of difference, which are not obviously the consequences of further growth, are the different plane of compression and the presence of a pharyngo-cloacal slit.

As to the former, it is a pure abnormality. By Professor Lankester's kindness I have had an opportunity this year of examining in detail the collections of Tunicates in the Oxford Museum, and I found there a specimen of *Phallusia mammillata* which exemplified precisely the same kind of variation. The broadly ovate test was compressed dorso-ventrally, the apertures and ganglion being in the middle line of the upper side, and the viscera and visceral septum of the test being correspondingly rotated. Yet there were no structural differences at all to warrant a division of the species.

As to the pharyngo-cloacal slit, its presence in the adult and not in the young may seem surprising, especially when its supposed morphological importance is taken into account; but I have found exactly the same phenomena in the species *Ascidiella aspersa*. The ordinary specimens of that species show no trace of this aperture, but I have seen a distinct pharyngo-cloacal slit in a particularly large individual, taken from a Falmouth trawler, which I examined this year at Plymouth; in it the slit* occupied its usual position

* The walls of the slit were definite, straight, and smooth, resembling in all respects those of the slit in *Ascidia mentula*. It must not be imagined that the slit, which I have mentioned, was an irregular abnormality of the kind described by Prof. Herdman in specimens of *Ascidiella aspersa* from the west coast of Ireland (Proc. Liv. Biol. Soc., v, 1891, p. 210, pl. x), an abnormality which may also occur in *Ascidia mentula*, as I have myself observed in a specimen from Loch Long.

opposite the cloacal aperture. It may therefore be admitted that the presence of this slit is in some way a consequence of increased size, and that its absence in young individuals is not a matter of specific value. An attempt to explain the meaning of this remarkable aperture is made below (see p. 132).

II.

Ascidia depressa, *Alder.*

Ascidia depressa, *Alder.* Cat. Moll. North. Durham, Trans. Tyneside Nat. Field Club, 1848, p. 107.

— — *non Heller.* Untersuch. über die Tunicaten d. Adriat. Meeres, Denks. d. Kais. Akad. Wiss. Wien., xxxiv, ii, 1875, p. 15, Taf. v, figs. 10—12.

— — *nec Herdman.* Notes on British Tunicata, Journ. Linn. Soc., xv, 1881, pp. 286, 287, pl. xviii, figs. 4, 5.

— — *nec Roule.* Rech. s. les Ascidies Simples d. Cotes de Provence, Ann. Mus. d'Hist. Nat. Marseille, tom. ii, 1884.

Under this name I describe a species of Ascidian of which I took four specimens on May 11th. They were attached to the under surface of a stone near the Zostera bed off Nodes Point.

Specific diagnosis.—*Body* oblong ovate, much depressed, greenish when alive, attached by the whole of the left side. *Oral aperture* subterminal; *cloacal* two thirds of the way down, on the right side, near the dorsal edge. *Test* rather thin, cartilaginous, provided with numerous minute tubercles on its free surface. *Oral* and *cloacal siphons,* especially the cloacal, rather long. *Stomach* rounded, at the posterior end of the body; first bend of intestine considerably anterior to the cloacal siphon; rectum directed obliquely forwards, sometimes almost horizontal. *Tentacles* 25 to 30, long and slender. *Præbranchial zone* studded with minute papillæ. Aperture of *dorsal tubercle* horse-shoe shaped, horns not incurved, concavity anterior. *Ganglion* much elongated, slightly dilated at each end. *Epipharyngeal groove* low, moderately long. *Dorsal lamina* continued behind the œsophageal opening, fairly deep, strongly ribbed on the convex side and regularly pectinated, with stout papillæ profusely scattered on the concave side. *Pharyngeal wall* minutely plicated; horizontal bars usually broad and narrow alternately, their breadth never exceeding half the length of the meshes; internal longitudinal bars slender; papillæ above the connecting ducts erect, discoid, provided with a supporting ridge in front and behind; no intermediate papillæ; meshes square, each containing four or five stigmata. *Œsophageal aperture* on dorsal side of pharynx, near its posterior end.

The *body* in all the specimens is much depressed, oblong in form, with sloping and expanded edges, and attachment is affected by the whole of the left side. The position of the oral and cloacal apertures is indicated in fig. 7 (Pl. VII), which represents the largest individual of twice the natural size. The cloacal aperture varies

slightly in position, but it is always nearer the posterior than the anterior end of the body, between half and two thirds of the way down the dorsal edge. Both apertures are small and inconspicuous; no ocelli were observed in the living animal.

The dimensions of the largest specimen are as follows:

Maximum length	. . . .	$\frac{15}{16}$ inch
,, breadth	. . .	$\frac{5}{8}$,,
,, thickness	. . .	$\frac{1}{4}$,,

The *test* is firm and cartilaginous, though rather thin; it is not rough to the touch, but its surface is in reality studded with minute tubercles of bluntly conical form. They are so small that they cannot be readily observed when the test is immersed in alcohol, but when removed for a moment from the fluid, the presence of minute projections is detected by the broken reflection of light from its upper surface. A portion of the surface of the test is shown on Pl. VII, fig. 9, considerably magnified. A series of vertical sections through the test shows that the tubercles are quite solid, and that the culs-de-sac of the test-vessels have no connection with them. The greater part of the test is composed of huge "bladder-cells," the largest of which are as large as many of the tubercles on the surface; they are of spherical or polyhedral form. The superficial tubercles are entirely destitute of bladder-cells.

The body when deprived of the test is at least twice as long as broad in the majority of the specimens, but in one individual the proportion between the two dimensions is slightly less than this. The oral and cloacal siphons are both rather long and tubular, and the cloacal siphon is particularly so (Pl. VII, fig. 8).

From the œsophageal opening being situated near the posterior corner of the pharynx, the viscera extend to the posterior end of the body. The *stomach* is rounded in form and considerably wider than the intestine. The course of the intestine has been sufficiently indicated above.

The *ganglion* is remarkably elongated, being six times as long as broad; it extends from the level of the fifteenth to that of the twenty-first horizontal bar in the specimen shown in figs. .

The *epipharyngeal groove* in the same individual is a low furrow, not elevated behind, extending from the dorsal tubercle as far as the ninth horizontal bar, but at the sixth bar its left lip suddenly thins out and bends over the right lip, concealing it from view, and continuing posteriorly as the *dorsal lamina*. This structure has a very characteristic form in this species (Pl. VII, fig. 10). It is moderately deep, provided with a regular succession of transverse ribs on its convex side and of well-marked teeth on its edge, the latter corresponding to the number of ribs. There are no inter-

mediate pectinations of its edge ; but the concave side, instead of being smooth, as is usually the case in Ascidians, is profusely studded with stout papillæ, as shown in the figure. There is a certain tendency of the papillæ to be arranged in rows directed obliquely from the summit to the free edge of the lamina, from before backwards ; but this general tendency is frequently departed from. The dorsal lamina is continued for some distance behind the œsophageal aperture.

Branchial apparatus.—The horizontal vessels are often of two sizes,* broad and narrow, and these vessels alternate with one another in position ; but the breadth of the larger vessels never exceeds half the antero-posterior diameter of the meshes—usually it is considerably less. The pharyngeal wall is minutely plicated. The internal longitudinal bars are slender in form. At their junctions with the connecting ducts are situated blunt papillæ of characteristic shape ; they are of an erect discoid form, with a semi-circular edge, compressed from before backwards, and provided with a supporting ridge or buttress upon their anterior and posterior faces (fig. 11 *b*). Usually the meshes are square, and intermediate papillæ quite absent; but in some parts of the pharynx transverse rows of meshes may frequently be observed which are distinctly elongated in a longitudinal direction, and in such regions minute intermediate papillæ may be detected upon the internal longitudinal bars. The elongation of the meshes and appearance of intermediate papillæ is preparatory to the formation of a new series of horizontal vessels, in the manner which I have described above in *Ascidia mollis*. There are four or five stigmata in each mesh (fig. 11 *a*). There is no pharyngo-cloacal slit.

My largest specimen is mature, and minute white ova are present in the oviduct.

After much consideration I have arrived at the conclusion that the specimens whose structure I have just described represent the species *Ascidia depressa* of Alder, and that the Ascidians described under this name by Heller, Herdman, and Roule, are distinct from it.

A reference to Alder's original account will show how perfectly in every point my specimens agree with his description, with the exception that I can make no statement as to the presence of red ocelli around the apertures. I did not observe these spots in the living animals ; but on the other hand I paid no attention to the point, and probably overlooked their existence. In every other respect the correspondence is complete, and I may draw especial attention to the following details—the shape and colour ; the expanded edge ; the position and form of the apertures ; the granulations (minute tubercles) on the upper surface ; the absence of inter-

* This distinction of size is much less apparent in mature than in young individuals.

mediate papillæ in the branchial sac (for it was Alder's habit to imply the absence of these structures when he made no direct reference to them); and the size.

If this be really so, it necessarily follows that Heller's specimen described under the same name is distinct. The structure of the test is alone sufficient to distinguish my specimens from his. The bladder-cells in the former are huge, of spherical or frequently polyhedral form, exactly as Heller has himself described and figured for his *Ascidia rudis* (l. c., p. 14, Taf. v, fig. 6); but for his *A. depressa* a very different condition was described by him (l. c., p. 15). Further, Heller's *A. depressa* was destitute of the superficial microscopic tubercles which are present in my specimens (and in Alder's), and which Heller himself also figured for another species (*A. rudis*, l. c.).

Secondly, the specimens which Prof. Herdman has referred to this species differ from Alder's in possessing intermediate papillæ on the internal longitudinal bars; Alder would certainly have noticed the existence of such papillæ as Herdman has figured (l. c., *supra*, pl. xviii, fig. 4), if they had existed in his specimens. Prof. Herdman's specimens cannot belong to the same species as these from the Isle of Wight, because in the latter the internal longitudinal bars rarely show a trace of intermediate papillæ, except when the meshes have grown to a size when they are almost twice as long as broad; in Prof. Herdman's species these papillæ are normally present, and the meshes are elongated transversely. Further, the structure of the dorsal lamina is very different in the two cases. Prof. Herdman in the same paper noticed the existence of tubercles on the dorsal lamina of *Ascidia plebeia*, so that there is no reason to suppose that he overlooked them in his *A. depressa*.

Lastly, M. Roule has described under the name *Ascidia depressa*, a species which, while probably identical with Heller's, is undoubtedly distinct from Alder's species. The mode of attachment, the shape of the body, and the structure of the branchial sac are very different in the two cases. The species described by Heller and by Roule presents a close affinity with *Ascidia mentula*, and still more, perhaps, with Alder's (not Heller's) *Ascidia rudis*; but there is nothing in Alder's description of *A. depressa* to indicate a similar relationship for that species, and my specimens are distinctly against it.

Ascidia depressa, as now re-described, is very closely related to Traustedt's *Ascidia* (*Phallusia*) *pusilla* (Mitt. Zool. Stat. Neap., iv, 1883, p. 465, Taf. xxxiv, figs. 16, 17; Taf. xxxv, fig. 26). The chief points of difference are found in the different proportions of the length to the breadth of the body, the length of the siphons, the breadth of the largest horizontal vessels of the pharynx, the

number of stigmata in the meshes, the shape of the stomach, and especially the structure of the dorsal lamina. Some of these differences are trivial, and it is impossible at present to say whether Traustedt's single specimen of *A. pusilla* is, or is not, merely an abnormal individual of our species; but the constancy in the structure of the dorsal lamina in my specimens is, when associated with the other peculiarities, a strong piece of evidence in favour of the specific distinctness of the two types.

Ascidia depressa is also allied to *Ascidia marioni*, Roule, on account of the close agreement between the two species in the following points—the mode of fixation, the position of the apertures, the minute tuberculation of the surface, the absence of intermediate papillæ, the strong pectination of the dorsal lamina, the elongation and approximation of the stigmata; but the two species are of course quite distinct owing to the important difference between them in the structure of the subneural gland and its accessory organs.

I have already pointed out the curious resemblance between *Ascidia depressa* and Heller's *Ascidia rudis* in the histological and superficial structure of the test. Since Heller's specimen agrees with Roule's *Ascidia marioni* both in the position of the cloacal aperture and in the minute tuberculation of the surface, it is not improbable that the two are specifically identical; but whether Heller's individual was rightly referred to Alder's species or not is very doubtful. Alder's *rudis* possessed "small, *distant* tubercles" on the test, and was "sometimes nearly smooth,"—a condition very different from that in Heller's specimen, as well as in Roule's *A. marioni*.

If, as I believe it will now be generally admitted, the forms described by Heller, Roule, and Herdman under the name *Ascidia depressa* can no longer lay claim to that title, it will be necessary to refer to them under new designations. I would propose for the Mediterranean species described by Roule the name *Ascidia Roulei*. To the variety *petricola* of this species, Heller's specimen almost certainly belongs. I believe that *Ascidia Roulei* is closely related to, if not identical with Alder's *Ascidia rudis*: but it is impossible to give a final decision upon this question until our British Ascidians have been collected and re-examined in greater detail.*

The form described by Herdman as *Ascidia depressa*, in the paper to which reference has been made above, appears to be distinct from *Ascidia Roulei*, although it is impossible, from the want of correspondence between the descriptions, to speak decisively. But Prof. Herdman has himself thrown doubt upon their identity

* It is needless to say that we look forward with interest towards Prof. Herdman's promised re-description of some of Alder and Hancock's types.

in his recently published* Revised Classification of the Tunicata, so that a new name is, at least provisionally, desirable. I therefore propose for it the name *Ascidia Herdmani.*

The subjoined synonymic lists show briefly the conclusions to which I have been led by the study of this species from the Isle of Wight.

1. Ascidia depressa, *Alder,* 1848, loc. cit.

= Ascidia depressa, *Garstang,* 1891 (the present paper).
?? = Phallusia pusilla, *Traustedt,* 1883, loc. cit.
non Ascidia depressa, *Heller,* 1875, loc. cit. (= *A. Roulei,* Garstang, 1891).
nec — — *Herdman,* 1881, loc. cit. (= *A. Herdmani,* Garstang, 1891).
nec — — *Roule,* 1884, loc. cit. (= *A. Roulei,* Garstang, 1891).

2. Ascidia rudis, *Alder,* 1863. Ann. Mag. Nat. Hist. (3), ii, p. 195.

? = Ascidia Roulei, *Garstang,* 1891.
= A. depressa, *Roule,* 1884 (*non* Alder, 1863, *nec* Herdman, 1881).
= [var. petricola] A. depressa, *Heller,* 1875.
non — rudis, *Heller,* 1875.
? = A. Marioni, *Roule,* 1884.

III.

Ascidia mentula, *O. F. Müller.*

Ascidia mentula, *Müller.* Zoologia Danica, 1788, vol. i, pp. 6, 7, pl. viii, figs. 1—4.
— rubrotincta, *Hancock.* Ann. Mag. Nat. Hist., 1870.
— rubicunda, *Hancock.* Ibid., 1870.
— robusta, *Hancock.* Ibid., 1870.
Phallusia mentula, *Kupffer.* Jahresb. d. Komm. z. Unters. d. deutsch. Meere in Kiel, Berlin, 1874, p. 209, pl. iv, fig. 1.
Ascidia mentula, *Heller.* Untersuchungen, 1875, loc. cit., pp. 2—13, pls. i—iv.
— rubescens, *Heller.* Ibid.
— lata, *Herdman.* Journ. Linn. Soc., xv, 1881.
Phallusia mentula, *Traustedt.* Die einfachen Ascidien, 1883, loc. cit., pp. 457—459.
Ascidia mentula, *Roule.* Recherches, 1884, loc. cit.

Several large Ascidians, which I refer to this species, were found attached to the sides of a rock, situated far out in the Zostera bed off Nodes Point, on May 7th, at extreme low water,

* Journ. Linn. Soc. Zool., vol. xxiii, 1891, p. 594.

spring-tides having then almost reached their height. The following descriptions refer to two individuals which I brought away with me for more detailed examination; they are given separately in order to indicate the degree of variation the more naturally.

A. *Body* oblong, elongated, attached by almost the whole of the left side. Dimensions—Length, 3 inches; breadth, $1\frac{1}{3}$ inches; thickness, $\frac{11}{12}$ inch. An idea of its external appearance may be gained from the figure which Heller gives (l. c. pl. v, fig. 5) to represent a supposed specimen of Alder's *Ascidia rudis*, but the position of the cloacal aperture is different.

Test thin, hard, cartilaginous, greatly wrinkled in a longitudinal direction on the right side, almost entirely overgrown by small algæ, and extensive colonies of the Polyzoon *Alcyonidium mytili* and some Didemnids. Here and there on the right surface a few minute tubercles may be detected. *Oral aperture* on the right side, sub-terminal, not prominent, bounded by nine lips; *cloacal aperture* on the right side near the dorsal edge, very slightly nearer the anterior than the posterior end of the body, bounded by six lips.

Upon removal of the test the rest of the body is seen to be of a yellowish colour, the musculature being of a rather deeper amber-colour. The *oral* and *cloacal siphons* are tubular but short. The oral siphon terminates in nine sub-triangular lips, which are rather prominent, with rounded apices and with a spoon-shaped concavity on their external surfaces. The edge of the siphon is bounded by a thin red line which is discontinuous towards the tips of most of the lips. A small red ocellus is found behind the red line between each pair of lobes, and the surface of the siphon is slightly sprinkled with red dots. The cloacal siphon terminates in six lobes, bounded similarly by a thin red line, but without ocelli. It is directed straight towards its external orifice.

Musculature coarse and strong, the fibres amber-coloured.

Viscera disposed as usual in the species, the posterior border of the stomach being nearly $\frac{1}{2}$ inch from the posterior end of the body; the anterior wall of the intestine at its first bend is on a level with the ganglion; the posterior wall at its second bend is on a level with the opening of the œsophagus into the pharynx.

Renal vesicles large, forming a soft yellowish coating over the stomach and intestine; concretions showing as a small brown spot in each vesicle, when looked at with a lens, but resolving themselves in each case into a compact mass of several concretions, of different sizes and of a yellowish-brown colour, when examined under a low power of the microscope (cf. Roule).

Tentacles about thirty in number, short, of unequal sizes, irregularly arranged.

Præbranchial zone studded with microscopic papillæ arranged more or less regularly in longitudinal rows.

Dorsal tubercle longer than broad, presenting two apertures, one behind the other. The anterior is crescentic, with the horns produced and curved inwards; the posterior is crescentic, with the left horn slightly produced and curved towards the mid-dorsal line, and with the right horn also curved round and produced a little beyond the mid-dorsal line (Pl. VII, fig. 12).

Epipharyngeal groove present for a short distance and then ceasing abruptly (fig. 12). The *dorsal lamina* is quite absent anteriorly, and does not appear until halfway between the position of the ganglion and the level of the pharyngo-cloacal slit, when it gradually rises up in the form of a narrow membrane and is continued to the posterior end of the pharynx. Dorsal lamina strongly ribbed transversely and minutely pectinated at the margin, the teeth corresponding to the ribs; no intermediate pectinations; concave side smooth.

A *pharyngo-cloacal slit** present on the right side of the dorsal

* I give this name to the curious aperture, so commonly found in the pharyngeal wall of *Ascidia mentula*, in which species it was first noticed by Kupffer (l. c.). It has been ingeniously suggested lately that it represents the persistent internal opening of the right primitive atrial canal, in spite of the fact that it is absent in the more primitive Ascidians, such as *Clavelina* and the *Distomidæ*. Now, as has been stated above (pp. 123 and 124), I have discovered this slit to be present in large individuals of two other species of Ascidians which are not closely allied to *Ascidia mentula* (*Ascidiella aspersa* and *Ascidia mollis*), although it does not exist in young specimens of those species. This fact is a sufficient disproof of the theory which gives to the slit the value of a phylogenetic remnant. My own theory is less attractive, but possibly more true. The slit is always situated opposite the cloacal orifice, and only occurs in large species (*Ascidia mentula* and its close allies, *e.g. Ascidia lata*, Herdman) and in large individuals of smaller species (*e.g.* of *A. mollis* and *Ascidiella aspersa*). May it not be a special adaptation for the prevention of the over-accumulation of fæces in the cloacas of large Ascidians, where the ordinary methods of ejection are insufficient? Ascidians, being sessile animals, are especially liable to danger from such over-accumulation, as Giard long ago stated in the case of the *Didemnidæ* and *Polyclinidæ* (Arch. Zool. Exp., i, p. 520); and special means are adopted in various sections of the group to ward off the danger. For instance, as Maurice has well suggested, the cloacal languettes of the *Polyclinidæ* serve the definite function of keeping open the cloacal canals in colonies of that family (Arch. de Biol., viii, 1888, p. 243); while in the *Botryllidæ* the end is achieved only by the united efforts of the zooids in a cœnobium: they simultaneously and suddenly contract their bodies, and so drive a strong current of water through their peribranchial cavities into the common cloaca, ejecting the fæces with such violence, as Gaertner observed, "ut ingenti saltu oppositum faveæ marginem transiliant" (see Giard, loc. cit.).

In the large Ascidians under discussion, the presence of this big oval slit—it is frequently over a centimetre in length—directly opposite the cloacal cavity, will enable the animal, by a strong contraction of the muscular tunic, to drive a considerable body of water from the pharynx into the cloaca, and thus to effect the desired object more thoroughly than is possible when stigmata exist alone.

Kupffer has also recorded the existence of paired pharyngo-atrial slits, symmetrically

lamina, directly opposite the cloacal aperture; slit, $\frac{1}{4}$ inch long and smooth-edged.

Ganglion hour-glass shaped, midway between the slit and the dorsal tubercle.

Œsophageal opening high up in the pharynx, between the slit and the posterior third of the body. Behind it is a long smooth "post-buccal raphe" (see Heller's figure, l. c.).

Branchial apparatus.—Meshes elongated transversely; stout conical papillæ at the junctions, provided with supporting ridges in front and behind (fig. 13); intermediate papillæ equally long, but more slender than the primary papillæ; six or seven stigmata in a mesh; minute plications deep, the longitudinal furrows frequently bifurcating.

B.—The second individual differs from the one just described in the external form, and in the absence of any malformation of the dorsal tubercle and lamina; in other respects it is closely similar to the first specimen.

Body of a compressed pyriform shape, the narrow end anterior, attached by a circular area over the posterior half of the left side. Dimensions—Length, $2\frac{4}{5}$ inches; Maximum breadth across middle, $1\frac{3}{8}$ inches; Thickness, $\frac{3}{4}$ inch.

Test very slightly furrowed, overgrown with algæ and Polyzoa.

Oral aperture terminal; *cloacal* on the dorsal edge, slightly nearer the posterior than the anterior end of the body.

Oral siphon with very short and obtuse lips; no red pigment upon either of the siphons.

Tentacles forty in number, considerably longer than in the preceding specimen, irregularly arranged.

Dorsal tubercle circular in shape; aperture horse shoe-shaped, the right horn curved inwards.

Epipharyngeal groove considerably longer, its lips gradually narrowing and becoming continuous with the dorsal lamina.

In all other respects this individual agrees with the former.

Both individuals are mature and have ova and spermatozoa in their generative ducts.

I believe that in point of size these specimens have undergone a

placed in the posterior region of the pharynx, in *Ascidia conchilega* and *Ciona* [*canina*] *intestinalis*. The former species I have been unable to examine, but in *C. intestinalis* (preserved material) some individuals possess huge slits, through which the intestine conspicuously projects into the pharynx, while in other individuals no unusual apertures can be made out at all. (Cf. Traustedt, loc. cit., p. 455. Heller, loc. cit., ii, p. 118, seems merely to repeat Kupffer's statement. Roule, loc. cit., makes no reference to any exceptional openings.) I am inclined, therefore, to believe that in both these species Kupffer's apertures are accidental or artificial rather than natural.

considerable reduction since their capture. In the rough notes which I then made, I put down the length as "about 5 inches," while actual measurement now shows that the largest of the two brought away does not exceed 3 inches. Allowing for a possible degree of error in my original estimate of their size, there must still, I think, have taken place some contraction of their test and body in the four months during which they have been in alcohol. It is, I admit, unsafe to argue upon these grounds, for the larger ones may have been just those which I dissected at the time of capture and did not retain. I will, therefore, merely state that the size of some of the specimens which I found was fully 4 inches.

The *colour* of the individuals when alive was hardly different from that which these spirit specimens now exhibit. It is sufficient to say that there was an almost total absence of red pigment in their bodies, and what did exist was confined to the region of the siphons, particularly the oral siphon. The test-vessels, also, with their terminal dilatations, were destitute of red and of all conspicuous colouration.

The species *Ascidia mentula* has been described in greatest detail upon Mediterranean specimens, although it is widely distributed round all the coasts of Europe, and has been called the commonest of the British deep-water Ascidians. Off the south-western shores of England, however, it is certainly not common within the 40 fathom line; I have only taken it once or twice there, and its place seems to be occupied by two other large Ascidians, *Phallusia mammillata* and a coarse variety of *Ascidiella aspersa*. Indeed, the fact that there is extant no anatomical description of British specimens referred to Müller's species, seems at first to be strange, if they are really so abundant.

A comparison of my specimens with Müller's original description revealed some distinctions which at the outset seemed to be of some importance. Both of Müller's specimens were brilliantly pigmented, the whole of the body within the test being of a bright crimson colour, except over the area occupied by the viscera on the left side, which was whitish, the intestine being of a livid green colour ("colorem luridum exhibens").

But in Traustedt's specimens from Naples the red pigment was found to be a very variable and unreliable characteristic; sometimes the stomach only was so coloured, sometimes this pigment was spread over the entire area of the branchial sac (as in Müller's specimens), whilst sometimes individuals were taken which were quite destitute of red colouration.

Roule, at Marseille, has observed that the test is almost always

rose or red in colour, and he gives some beautiful figures in illustration of this condition, but he also admits a considerable degree of colour-variation in the species, which he attributes to local influences.

Heller's specimens from the Adriatic seem to have been much more subdued in colour than those from the neighbourhood of Naples and Marseille. He describes the colour as "greenish or yellowish-white, seldom brownish, the oral siphon usually edged with red (*rothgesäumt*);" further on he adds that the blood-corpuscles are brownish. My specimens, therefore, approach Heller's very closely in this respect.

Now a perusal of Hancock's paper on *Several New Species of Simple Ascidians* (1870, l. c.) shows that he attached a considerable importance to distinctions of colour in his definitions of species, an importance which can no longer be admitted for *mentuloid* forms at any rate; and Roule has quite rightly, in my opinion, merged Hancock's *A. rubro-tincta* into the species *A. mentula*. *Ascidia rubicunda* of Hancock agrees perfectly with the typical *mentula* of Müller in its brilliant colouration, and I shall show below how unimportant is the only other character which distinguishes it from the general form of that species. *Ascidia robusta* of Hancock is distinguished from the specimens which I have described from the Isle of Wight by hardly any other point than the prolongation of the oral and cloacal siphons.

It may be observed that in all the *mentuloid* forms there is a distinct correlation between the position and extent of the area of attachment and the zone of the sea-bed from which individuals have been taken. The *Ascidia mentula* of authors is an inhabitant of the deeper waters, and is found attached usually to stones and shells by its base and a very little of the left side. Adhering in this way, it is obvious that it has an erect position upon the sea-bottom. Now the three species named above were distinguished by Hancock from *Ascidia mentula* partly on account of the mode of their attachment; *A. rubrotincta* adhered "by the middle portion of the side," *A. rubicunda* "by the whole side with imperfect marginal expansions," *A. robusta* "by the whole side, but [was] sometimes much distorted, and with adherent root-like prolongations."

These three "species" were all taken from between tide-marks, the first at Guernsey, the second at Tobermory (Isle of Mull), Portaferry (Strangford Lough), and Bertraghbuy Bay (Connemara), the third at Herm.

The Isle of Wight specimens also were attached by the whole or the greater part of the left side, and they also were taken from a rock at low water.

Now no one can have much attended to the conditions of existence in the littoral zone without having been impressed by the extent of the disturbing forces which littoral animals have to resist, if they are to survive in that locality. They are battered by the waves almost incessantly, and cannot exist without special means of defence. This defence in many groups is ensured by the development of strong adhesive or clinging organs, the prevalence of which among littoral animals shows, by a reversal of the argument, the extent of the disturbing forces that play around them.

Tunicates are essentially plastic creatures, for the structure and mode of development of their tests renders their external form easily modifiable. It would, therefore, be extremely improbable to find that the larvæ of *Ascidia mentula*, when carried by in-flowing tidal currents from deeper water into the littoral zone, would grow in quite the same way in one place as in the other. The incessant motion of the water would necessitate, and indeed frequently bring about, as growth proceeded, a larger area of attachment than would suffice to resist the comparatively feeble currents of deeper water.

The results of such a process would be (1) Hancock's *Ascidia rubicunda*, which is merely the red-coloured variety of *A. mentula* adapted to a littoral existence; (2) my specimens from the Isle of Wight, which are merely the pale variety of *A. mentula* adapted to a littoral existence upon a comparatively smooth surface of rock; (3) Hancock's *A. robusta*, which is a pale reddish variety modified in its mode of attachment by tidal influences, and in its general shape by the irregularity of the surrounding objects ('roots' of *Laminaria digitata*).

Even Müller a hundred years ago recognised the plasticity of form in his species, for, referring to the oral and cloacal apertures, he says:—"Pro figura massae, quae ab adjacentibus corporibus determinatur, vel utraque lateralis, vel altera plerumque terminalis."

If it should be objected that the Mediterranean zoologists can supply little or no evidence of variability in the extent and mode of attachment in their specimens, the fact is rather in favour of my contention than against it; for the causes to which the variation has been here attributed are absent in the Mediterranean, where the tidal oscillation, with its accompanying disturbance of the sea-bottom, is so small that it may practically be neglected.

With regard to internal structure, the differences between the Isle of Wight specimens and those described by the Mediterranean zoologists are very slight and unimportant.

For a comparison of the descriptions of Mediterranean forms shows that variability is not confined to points of colour and external form. Traustedt gives the number of tentacles as from

78 to 85 in Neapolitan specimens, while Heller, who also examined the species in great detail, ascribes from 30 to 35 to Adriatic examples. There are 30 in one of mine, 40 in the other. Herdman's *Ascidia lata* ($3\frac{1}{2}$ inches long; one specimen) possessed from 16 to 20, and the species was defined upon the ground of this difference* and of a peculiarity in the aperture of the dorsal tubercle.

Take again the dorsal lamina. Heller unfortunately gives no details upon this point, but Traustedt and Roule agree that the lamina is strongly pectinated. In Roule's specimens the right face of the lamina is also provided with a few smaller "languettes." On the other hand, Hancock's *A. rubicunda*, Herdman's *A. lata* (from Loch Long), and my specimens agree in being merely minutely denticulated along the edge of the lamina.

It is true, therefore, that we have at last arrived at a point wherein some of the north Atlantic forms agree to differ from their Mediterranean relatives; but he would be rash who would distinguish the species upon this ground alone, in view of the numerous cross-resemblances in other respects.

The præbranchial zone is minutely tuberculated in my specimens just as in Traustedt's.

Altogether, therefore, there appears to be no sound reason why the numerous *mentuloid* forms mentioned in this paper should not be grouped together into one species and entitled *Ascidia mentula*. Some other "species" might even be added to the list. Heller's *A. rubescens* has rightly been included by Roule as a young individual of the species, and it is just possible that Herdman's *A. fusiformis* ($1\frac{5}{8}$ inches long; three specimens) is merely a young condition also.

It is difficult to form an opinion upon Hancock's *A. plana* and *A. alderi*; but they appear to belong to this species also.

I cannot hope to have altogether avoided error in the course of this paper, but I have certainly endeavoured to do so; and I trust that, as an attempt to throw a little light upon some of our British Tunicates, my essay will not be without useful results.

Moreover, it would seem to be serviceable if a word or two should be said upon the desirability of keeping in mind the facts of variation, and of adopting some method by which the broad phenomena of variability within the limits of a species can be properly and systematically recorded.

* Since the above was put in type, I have been enabled to examine some specimens of *A. mentula*, which were dredged in Loch Long and are now under Mr. Hoyle's charge in the Manchester Museum. The number of tentacles is so variable as to be only 18 in an individual $4\frac{3}{4}$ inches long, while it is nearly 40 in an individual 3 inches long.

It is now a truism that variation does not only consist in the manifestation of irregular abnormalities. The commonest Anemone of our sea-coasts, *Actinia equina*, Linn., sufficiently testifies to the existence of a fixity and a stability even in variation. Yet it would be a strange misconception of the species-idea that would lead anyone to specifically separate the more constant varieties of *Actinia equina* or of *Cylista undata* from one another simply on the ground of that constancy.

The *nomen triviale* of taxonomy is a great boon to the investigator in biology, but it becomes a burden when it is applied with random pen to every little group of forms, distinguished though they may be, under their particular conditions, by the constant possession of some minute peculiarity. Minute and constant peculiarities are of the greatest interest and importance, and nothing could be, for some time to come, of higher value to the student of organic evolution than their careful recognition and classification, involving also a similar record of the bionomical conditions under which those peculiarities are found to be manifested.

But there is no reason why the specific name should be bestowed upon these minutely isolated groups. They had much rather have a nomenclature of their own within the limits of the species embracing them ; and that such a nomenclature can be adopted with success is sufficiently established by a perusal of Mr. Gosse's admirable monograph of the British Actinians,—to go no further.

I will conclude with an attempt, by way of illustration, to record what seem to be the main outlines of variability in the species which has just been discussed.

ASCIDIA MENTULA, *O. F. Müller.*

Var. 1.—RUBERRIMA. Body-walls beneath the test of a brilliant red or rose-colour; tentacles (always ?) numerous (60 to 80).

Form *α.*—*Erecta.* Area of attachment small, usually posterior and basal; infra-littoral.

Distribution.—Off the south coast of Norway; Mediterranean, off Marseille and Naples, rare in Adriatic (= *A. rubescens*, Heller).

Form *β.*—*Depressa.* Area of attachment large, extending over the whole or the greater part of the left side; littoral.

Distribution.—West coast of Scotland, west and north-east coasts of Ireland (= *A. rubicunda*, Hancock).

Var. 2.—RUBROTINCTA. Body-walls tinged with reddish flesh-colour.

Form *α.*—*Erecta.* Attached as described above; infra-littoral. Naples, Marseille, British seas ?

Form β.—*Depressa.* Attached as described above; littoral.
Channel Isles (= *A. rubrotincta* and *A. robusta*, Hancock).

Var. 3.—RAVA. Body-walls yellowish, with little or no trace of red; tentacles rarely exceeding 40 in number.

Form α.—*Erecta.* As above; infra-littoral.
Adriatic. [West coast of Scotland (= *A. lata*, Herdman; but the colour of this race is only known from spirit specimens).]

Form β.—*Depressa.* As above; littoral.
Isle of Wight.

DESCRIPTION OF PLATES VI AND VII,

Illustrating Mr. W. Garstang's paper "On some Ascidians from the Isle of Wight."

N.B.—All the figures were drawn from preserved material.

PLATE VI.

FIG. 1.—*Ascidia mollis*, Ald. and Hanc. The largest normal individual, nat. size.

FIG. 2.—*A. mollis.* Culs-de-sac of the test-vessels, magnified.

FIG. 3.—*A. mollis.* Another individual of smaller size, as seen after removal of the test; twice the natural size.

a. = View of the right side, showing the musculature.
b. = View of the left side, showing the disposition of stomach and intestine.

FIG. 4.—*A. mollis.* Portion of the pharyngeal wall of the same individual; much enlarged. Zeiss, Obj. A. Oc. 2, Cam. luc. The dark portions represent the longitudinal furrows, the light portions the elevations which are caused by the "minute plication" of the wall.

c.d. = Connecting ducts between the horizontal and the internal longitudinal vessels.
h.v. = Horizontal vessels, forming three complete series and a rudimentary fourth.
i.l.b. = Internal longitudinal bars or vessels.
i.p. = Intermediate papillæ.
p. = Papillæ on the int. long. bars above the connecting ducts.

FIG. 5.—*A. mollis.* The large abnormal individual, nat. size.

a. = View from above the dorsal surface. The left side consists entirely of the area of attachment; the right side forms an elevated ridge. The inconspicuous slit-like oral and cloacal apertures are indicated.
b. = View of the opposite surface.

FIG. 6.—*A. mollis.* The same with the test removed, in the same position as in fig. 5 *a.* Nat. size.

an. = Anus.
c.s. = Cloacal siphon.
gn. = Ganglion.
int. = Intestine—the descending portion.
œs. = Œsophagus.
o.s. = Oral siphon.
ov. = Oviduct.
pc. = Pericardium.
st. = Stomach, covered with renal vesicles.
v.d. = Vas deferens.

PLATE VII.

FIG. 7.—*Ascidia depressa,* Alder. The largest individual, twice the natural size.

FIG. 8.—*A. depressa.* The same, with the test removed, viewed from the left side, showing the course of the viscera, and the rather elongated siphons.

FIG. 9.—*A. depressa.* A portion of the test, magnified, showing the papillæ on its surface.

FIG. 10.—*A. depressa.* A portion of the dorsal lamina, magnified, showing the marginal teeth (*m.t.*) and the lateral papillæ which project from its concave surface. Camera lucida.

FIG. 11 *a.*—*A. depressa.* A portion of the pharyngeal wall, magnified. Camera lucida.

h.v. = Horizontal vessels.
i.l.b. = Internal longitudinal bars or vessels.
p. = Papillæ above the connecting ducts.
r.i.p. = Extremely rudimentary intermediate papillæ, here and there present where the meshes are elongated.

FIG. 11 *b.*—*A. depressa.* An enlarged view of the junction between an internal longitudinal bar (*i.l.b.*) and a horizontal vessel (*h.v.*), showing the form of the disc-shaped papilla (*p.*), with its anterior (*a.b.*) and posterior buttresses.

FIG. 12.—*Ascidia mentula,* O. F. Müller. The peritubercular area in the individual A., showing the double aperture of the dorsal tubercle.

ep.gr. = Epibranchial groove.
p.gr. = Pericoronal groove.
p.z. = Præbranchial zone, studded with minute papillæ.

FIG. 13.—*A. mentula.* Portion of an internal longitudinal bar (*i.l.b.*), seen obliquely from the side, showing the form of the papillæ on its surface; magnified. Camera lucida.

c.d. = Connecting duct.
h.v. = Horizontal vessel.
i.p. = Intermediate papillæ.
p. = Papillæ.

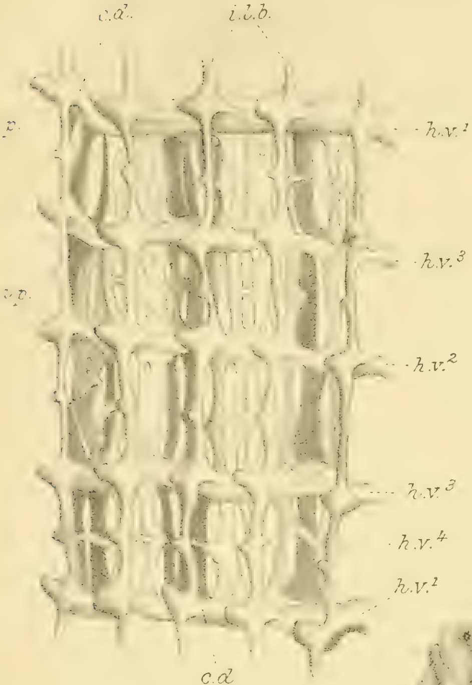


Fig. 4.

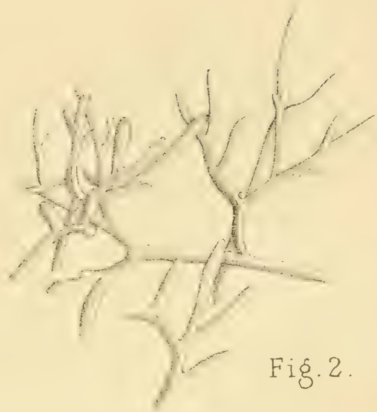


Fig. 2.


Fig. 1.


a. b.
Fig. 3.

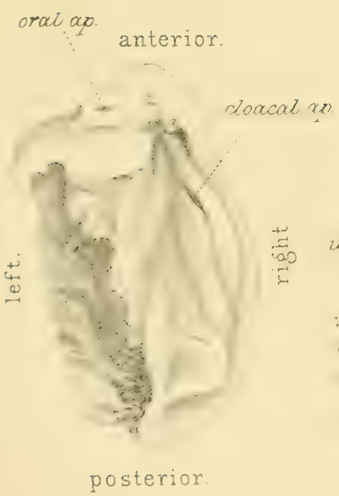
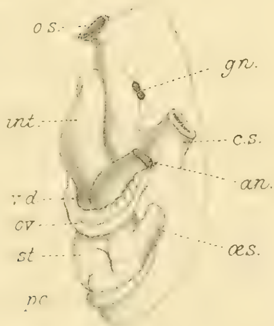


Fig. 5. a.



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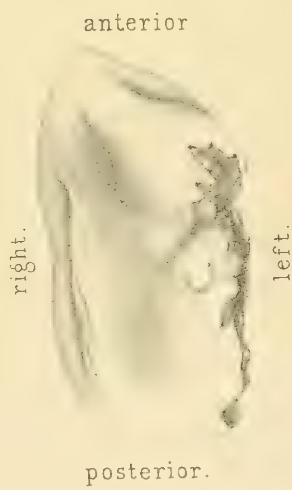


Fig. 5. b.

Fig. 7.

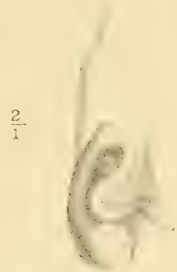
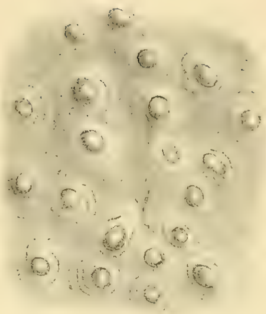


Fig. 8.



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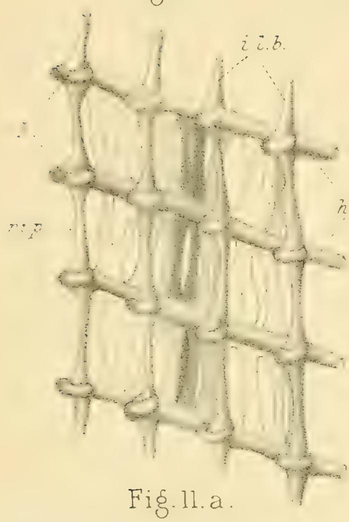


Fig. 11. a.

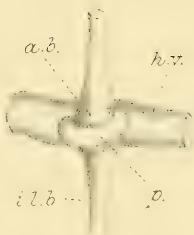


Fig. 11. b.

Fig. 10.

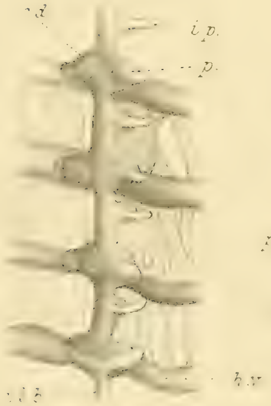


Fig. 13.

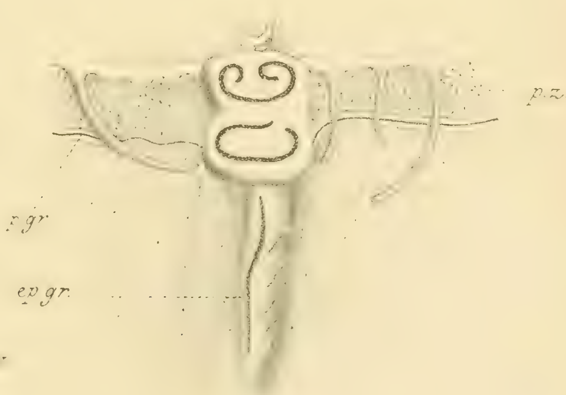


Fig. 12.

W. Garstang del.

F. Huth, Lith^r Edin^r

On the Development of Palinurus vulgaris, the Rock Lobster or Sea Crayfish.

By

J. T. Cunningham, M.A.

With Plates VIII and IX.

1. *Historical Review.*

The history of our knowledge of this subject is complicated and curious, and is not quite correctly narrated in any English publication, not even by Balfour in his account of the development of Crustacea (Comparative Embryology, vol. i). The story begins with the establishment and definition of the genus *Phyllosoma* by Leach in 1818. Various succeeding zoologists included descriptions of species of *Phyllosoma* in their works, but the result of all previous investigations are included by Milne Edwards in the comprehensive account of the genus given in his Hist. Nat. des Crustacés, vol. ii, 1837. The state of knowledge at that time may be briefly summarised as follows :—The Crustaceans known by the name *Phyllosoma* had been found near the surface of the ocean in various parts of the world. They varied in size from less than half an inch to two inches. They were, when alive, of glassy transparency ; the body was remarkably flat, and expanded horizontally, while the limbs were long, slender, and biramous. The body consisted of three parts ; firstly, a head having the form of an oval leaf, bearing at its anterior extremity a pair of eyes on long stalks and two pairs of simple antennæ. The mouth was situated beneath the middle or posterior third of the head, and surrounded by an upper and lower lip, a pair of mandibles, and the first pair of maxillæ. The second pair of maxillæ and the first pair of maxillipeds were rudimentary and

situated behind the mouth. The second part of the body was the thorax, quite as flat but not so large as the head; it was usually broader than long. It presented no trace of a division into segments, but on its lateral edges carried four to six pairs of long, delicate, articulated limbs, each of which was provided with a secondary shorter branch fringed with hairs on each side. The disposition of the abdomen varied; in some species it was distinctly marked off from the thorax and much narrower, sometimes situated in an emargination of the posterior edge of the thorax, and sometimes again it was at its base as broad as the thorax, of which it formed a direct continuation. Usually six or seven segments were visible in the abdomen, the last of which bore biramous flat appendages, like those of the lobster, on each side of the telson. According to these differences in the abdomen, Milne Edwards divided the species of *Phyllosoma* into three groups: (1) those which had a distinct well-developed abdomen, narrower than the thorax, *Phyllosomes ordinaires;* (2) those in which the abdomen was rudimentary, and situated in an emargination of the thorax, *Phyllosomes brevicaudes;* (3) those in which the abdomen was broad and continuous with the thorax, *Phyllosomes laticaudes.*

Since the date of Milne Edwards' work, various more or less incomplete researches have proved that the forms belonging to the genus *Phyllosoma,* as defined by the characteristics just described, are the early stages or larvæ of *Palinurus* and its allies, that is, of the Decapod Crustaceans of the family Palinuridæ or Loricata. Balfour, in his Comp. Embryology, vol. i, p. 477, states that the true nature of *Phyllosoma* was first shown by R. Q. Couch in a paper on *The Metamorphosis of Decapod Crustacea* in the Report of the Cornwall Polytechnic Society of 1848, but that Couch did not recognise the identity of his larva with *Phyllosoma,* which was first done by Gerstäcker. This statement is incorrect, probably because Balfour was unable to refer directly to the Reports of the Cornwall Polytechnic Society, to which I have access in the library of the Plymouth Institution. R. Q. Couch's first paper on *The Metamorphosis of Decapod Crustaceans* is in the Report of the said Society for 1843. The description of the newly hatched *Palinurus* there given is quite erroneous. Couch states that he obtained gravid specimens of *Palinurus* from the fishermen, and kept them in crab-pots until the eggs hatched. His description of the hatched larva is as follows:—" The whole animal is smaller and more slender than the young of the lobster. The body is oval, slightly depressed; eyes rather small compared with other species, sessile, marked at its circumference with radiating lines, and situated on a festoon of the dorsal shield. The claws are in four pairs, similar to those of

the adult, and rather long. The tail is long, extended, and composed of five unequal annulations; it is generally semi-flexed on the abdomen and hid among the claws. On the four superior rings of the tail are situated four pairs of long slender appendages. They are attached to the rings by joints, similar to those of the true claws. At a short distance from the basal joint these organs branch into two long slender branches, which extend nearly one third as long again as the tail; hence the posterior part of the body has a very bushy appearance. The termination of the tail is formed of two small fan-shaped expansions, separated by a shallow notch."

Couch gives a figure of the larval Palinurus in profile, which is as fictitious as his description. It is evident from the description, that he mistook the thorax of the larva for the abdomen, and regarded the true rudimentary abdomen as the last joint of the "tail." In his figure the thorax appears cylindrical instead of flat, and the four long characteristic thoracic limbs of the *Phyllosoma* are represented by four biramous appendages having a filamentous appearance. But the extraordinary thing is that in the figure, as in the description, there are four unbranched appendages in front of the four biramous, attached to the cephalic portion of the larva which Couch mistook for the cephalothorax. Since, in reality, there is only one elongated articulated appendage in front of the four biramous, namely, the second maxilliped, and as the rest of the oral appendages are quite small and visible only under a lens, it is extremely difficult to understand how Couch invented his figure. It is possible that he supposed all the long appendages that he saw, four pairs, to be on one side, those of the other side being invisible; in this way he may have reached his conclusion that there were eight pairs of limbs in all, four claws on the " body " and four slender appendages on the tail. However this may be, this first description is quite worthless, and there is no reference in it to *Phyllosoma.*

In the Report of the same Society for the following year, 1844, there is a second paper on the *Metamorphosis of Decapod Crustacea,* but all that it contains concerning *Palinurus* is that the young had been examined again with the same results as before.

In the Report of the Meeting of the British Association in 1857 there is a short paper by R. Q. Couch, entitled *On the Embryo State of Palinurus vulgaris.* The description of the larva there given is much more correct than that previously published by the same observer. It runs thus :—" The carapace is globular, oval, slightly pointed or produced both at the anterior and posterior margin, and also slightly contracted anteriorly, so as to give the appearance of a rostrum. The abdomen is moderately long, and from four of the six annulations of which it is composed arise eight pairs of tendril-like

appendages. These tendrils are long, slender, and dichotomous. Their double character commences at the third joint; for the remainder of their length they are nearly equal, and are covered with strongly marked spines; their termination is pointed. The caudal extremity is simple, contracted, pointed, and somewhat oval; on the centre of the rostrum is a dark spot; the eyes are placed on enormously long and stoutly club-shaped peduncles, which are attached by very narrow and slender points. The pedunculated eyes are about two-thirds as long as the carapace. The contrast between the young of the present species and others is very great. In them the eyes are sessile; in this enormously pedunculated. In them the limbs are beneath the carapace; in this they are attached to what, for clearness, I have called the abdominal rings. Instead, therefore, of belonging to the genus *Zoe*, this would be placed in *Phyllosoma* of Milne Edwards, as belonging to the Stomapodes."

Here, then, although it is evident Couch did not know much of the morphology of Crustacea, we have a great improvement on his former description. He evidently means to describe four pairs of biramous appendages; he mentions the long peduncles of the eyes, and the median eye (dark spot he calls it) on the rostrum. In this paper the comparison of the larva of *Palinurus* with *Phyllosoma* is made for the first time, although the importance of the comparison remained to be developed by men who understood the structure of Crustaceans better than Couch. In the British Association Report no figures accompany Couch's paper, but it is reprinted in the Natural History Review, vol. iv, 1857, with a plate (pl. xvii). On this plate is given a figure of the *Palinurus* larva from the ventral aspect. The figure is recognisable, though not very accurate. It gives fairly well the general shape of the body, the eyes, antennæ, and four pairs of long thoracic appendages. But the shape of the thorax is incorrect, as also that of the appendages, especially of the exopodites, while the appendages in front of the third maxilliped are entirely wanting from this figure and the rest of the plate.

In a *Report on the Progress of Entomology* in the Archiv f. Naturgeschichte, 1858, Gerstäcker speaks of the similarity of Couch's figure of the *Palinurus* larva with *Phyllosoma*, but does not mention that Couch made the comparison himself.

Independently of Couch, Gerbe in 1858 made the observation that the newly hatched larva of *Palinurus* had the characters of the genus *Phyllosoma*. Gerbe's studies were made at the Laboratory of Concarneau in Brittany, and were briefly described by Coste in the Comptes Rendus of 1858. Coste's publication was not accompanied by figures, but stated that Gerbe would be able, from material supplied by the aquaria of Concarneau, to publish at a future time a

full account of the metamorphoses of *Palinurus,* an object which has never yet been realised either by Gerbe or anyone else.

In 1863 Claus, in an account of observations made at Messina (Zeit. f. wiss. Zool.), described the embryo of *Palinurus* before hatching, and compared it with young *Phyllosomata* captured in the sea. He found differences in this comparison which appeared to him inexplicable on the view that *Phyllosoma* was the larva of the *Palinuridæ.* Spence Bate also came forward to oppose the correctness of the conclusions of Couch and Gerbe, in a paper in the Ann. and Mag. Nat. Hist., ser. 4, vol. ii.

Dohrn, however, in 1870 (Zeit. f. wiss. Zool.) published an important confirmation of the identity suggested by Couch and Gerbe. He gives a description of the development of *Scyllarus* in the egg, and of the newly hatched larva, which he shows to be identical with the smallest *Phyllosoma* obtained by Claus from the sea. He shows that the second maxilla gets smaller during the end of the embryonic period, while the first maxilliped disappears altogether before hatching. The second antenna is much shorter than the first.

In the embryo of *Palinurus,* at an early stage, the second antenna is longer than the first; the second maxilla is biramous, the inner branch smaller than the outer. The first maxilliped is at first distinctly biramous, but the branching disappears; the appendage becomes simple, but does not disappear as in *Scyllarus.* The abdomen is rounded at the end, and the last pair of appendages is indicated. In the embryo, when ready to hatch, Dohrn states that the first maxilliped is quite short and thick, and appears to have a prominence near the base, which probably developes later into a branchial plate. Dohrn gives no figure nor further description of the hatched larva.

In 1873 Ferd. Richters published in the same Zeitschrift a paper containing the results of a critical examination of a large collection of specimens of *Phyllosoma* from the Hamburg Museum. Richters has shown by tracing successive stages in his specimens, and comparing them with the observations of Claus and Dohrn, that all those Phyllosomes which possess the following three characters belong to the genus *Palinurus,* which is distinguished from the other genera of its family, such as *Scyllarus,* by having long, cylindrical, multiarticulate second antennæ, whereas the others have short, flat, broad second antennæ with few segments. The three distinguishing characters of the *Palinurus* Phyllosomes are—

(1) The second antennæ are longer than the first in the earliest stages, and later on always remain cylindrical; while in the *Scyllarus* Phyllosomes the second antennæ are in the earliest stages much shorter than the first, and soon become broad and flat.

(2) The abdomen is sharply marked off from the thorax, being much narrower at its base than the latter.

(3) The articulation of the thorax with the abdomen is on the same level with the origin of the last pair of thoracic limbs.

Thus Richters shows that the forms which Milne Edwards distinguished as *Phyllosomes ordinaires* are the larvæ of *Palinurus*, or genera belonging to the *Palinurus* division of the *Loricata*.

But here we come upon a point which requires elucidation. Richters states that the first maxilliped is completely wanting in the youngest larvæ of the *Palinurus* series; he points out that Dohrn himself describes a reduction of the first maxilliped as having taken place in the embryo almost ready to hatch, and then says that this last stump also, without doubt, disappears, since in the youngest *Palinurus* Phyllosomes which he examined no trace of this appendage was to be discovered.

The last publication I have to refer to is Spence Bate's Report on the Decapoda macrura collected by the "Challenger." That author says concerning the larvæ of *Palinurus*, that it has been found impossible to keep them alive in aquaria any time after hatching, and that although, no doubt, there are large numbers of these larvæ in the sea off our south-west coast, only solitary specimens of the *Phyllosoma* form have been occasionally taken. Spence Bate does not figure the hatched larva of our common *Palinurus*, the true *Phyllosoma*, but gives instead a figure of the nearly ripe embryo taken from the egg, and this is by no means perfectly similar to the free larva. With regard to the question of the first maxilliped Spence Bates' descriptions throw no light upon it, as he does not go into the details of the oral appendages in his specimens. He was not apparently acquainted with Richters' paper, for he attributes to *Palinurus*, a specimen of *Phyllosoma* having the characteristics of those larvæ which Richters has shown to belong in all probability to *Ibacus* or *Paribacus*, or, at all events, to develop into forms with short, flat antennæ.

We find then, from the above survey of the literature that although it is clear that *Palinurus vulgaris* is developed from a *Phyllosoma*, no single figure or detailed description of any larval stage, known certainly to belong to this species, has been published except those of Couch, which are unsatisfactory. Claus has published figures of Phyllosomes taken at Messina, the smallest of which Dohrn proved afterwards to be identical with the larva of *Scyllarus arctus*, now called *Arctus ursus*, which also occurs, though rarely, in the neighbourhood of Plymouth. The newly hatched larva of *Palinurus* has been obtained in aquaria several times, *e.g.* by Gerbe at Concarneau, by Dohrn at Messina, and by Alfred Lloyd

at the Crystal Palace. But no correct figure of it is in existence, nor have its later stages been described. I now proceed to the description of my own observations.

2. *Observations on the Larva of Palinurus vulgaris.*

In July, 1889, a large number of larvæ were hatched from a berried crayfish in one of our tanks at the Plymouth Laboratory, and I preserved some hundreds of these, but did not then study them. This year, on the 9th July, when I was working a large net made of mosquito netting at the surface, a little to the north of the Eddystone, I obtained a number of Phyllosomes of different sizes and stages. On the 16th I obtained a still larger number in the same net to the south of the Eddystone. Hitherto they have only been very rarely taken on the south coast of England, and then, according to Spence Bate, only solitary specimens. The reason of this seems to be merely that suitable nets have not been used in the right place at the right time of year. These larvæ apparently do not occur near shore, for we have never taken them before in our ordinary tow-nets worked within a mile or two of the coast. At any rate it is interesting to find that some hundreds may be taken in about an hour in the neighbourhood of the Eddystone in July, with a net whose meshes are about 2 mm. in diameter, and whose mouth is 8 feet by 6 feet in area. On the two occasions on which I obtained the larvæ, I captured them only when towing the net at the surface, not when it was sunk to some depth.

The newly hatched larva of *Palinurus* is 3·1 mm. in length from the anterior border of the cephalon to the posterior extremity of the abdomen. The second antenna is almost, but not quite, as long as the first, and neither of them is divided into joints. The thorax is provided with four pairs of very much elongated appendages, namely, the third maxilliped and the first, second, and third ambulatory limbs or pereiopods. These appendages all have six joints, and from the end of the second joint springs an exopodite consisting of a larger number of short joints, and fringed with long feather-like bristles. The exopodite of the third pereiopod is not completely developed, having slight indications of one or two joints and no bristles. Of the oral appendages, the mandibles and first maxillæ are fully developed and functional; the second maxilla is rather large and foliaceous, and extends away from the median line; the first maxilliped is not wanting, but rudimentary, being represented by a simple, small, but distinct conical stump. The second maxilliped is a slender six-jointed appendage, not extending beyond the

cephalon, and destitute of even the rudiment of an exopodite. The fourth and fifth pereiopoda are not yet developed, but represented by two minute rounded buds on either side of the root of the abdomen. The abdomen is without developed appendages, but the sixth pair of pleopods is indicated already by a slight rounded outgrowth on each side of the telson. The termination of the telson is truncated, without the slightest trace of bifurcation (Pl. VIII).

Among the Phyllosomes I obtained from the sea there are all sizes and stages, from the newly-hatched stage just described, up to one 7 mm. long, which is the largest and most developed I have yet obtained. The developments that have taken place at this stage are as follows :—The second antenna is now a little, but not much longer than the first. Two basal joints have been differentiated in the first antenna, and from the end of the second has grown out a simple process, the commencement of the internal filament. One nodal division is also visible in the basal portion of the second antenna. The exopodite has began to sprout out from the second joint of the second maxilliped, but the rudimentary stump of the first maxilliped, and the rest of the oral appendages, are quite unchanged. The exopodite of the third pereiopod is fully developed, and the fourth and fifth pairs of pereiopoda have developed considerably, the fourth being biramous and almost as long as the abdomen, the fifth still simple and somewhat shorter. The pleopods of the abdomen are considerably developed. The sixth pair or swimmerets are of some length and distinctly biramous, while the four preceding pairs are also visible, and each commencing to divide into exopodite and endopodite. No appendage is developed at all on the first abdominal segment. The cephalic shield which, in the newly-hatched stage, covered only the second maxilliped, leaving all the rest of the thorax with its appendages free, now extends back so as to cover the origin and base of the third maxilliped (Pl. IX).

There can be no doubt at all that the Phyllosomes I have obtained belong to *Palinurus vulgaris ;* Dohrn's and Richters' investigations have shown clearly that the larvæ of *Scyllarus* can be distinguished from those of *Palinurus* at all stages, and *Scyllarus arctus* (*Arctus ursus*) is the only other species of the family which occurs near Plymouth, and this form is very rare. It becomes possible, therefore, to identify the *Phyllosoma* larvæ of *Palinurus vulgaris* if they have been sufficiently described or figured in previous literature. It is not possible to identify satisfactorily the forms described by Milne Edwards and Richters ; they come from distant coasts, such as those of Africa, Asia, and New Guinea. However, it may be mentioned that Richters is very possibly wrong in stating that the first maxilliped was wanting in his youngest Palinurine form, 7 mm.

in length, since his figure of the appendages in this form is not conclusive, but suggests the idea that he has figured the rudimentary first maxilliped and mistaken it for the second maxilla.

It is more interesting to note that of the stages obtained and figured by Claus at Messina, while the oldest and youngest belong to *Scyllarus*, all the others, that is all those figured on Z. f. w. Z., Bd. xiii, pl. xxvi, are stages in the development of *Palinurus vulgaris.* The youngest of these stages is described as 4 mm. long, and therefore has not long been hatched. It agrees, except in one or two very minute details, due, I think, to slight mistakes in drawing, with the newly hatched larva I have described, and, above all, both in the description and figure of Claus, the first maxilliped is represented as a short papilla-like process, exactly similar to that in my specimens. Claus figures and describes two other stages, which also I identify as belonging to *Palinurus vulgaris;* one of these is 14 mm. long, the other 21 mm.; both, therefore, older than the oldest of my specimens. In the former, the thorax extends back over the third maxilliped in the older stage (21 mm.), still further, covering the base of the first pereiopod. In this oldest stage of Claus the antennæ have almost acquired the adult form, and the fourth and fifth pereiopoda are longer than the abdomen, although the fifth is still destitute of exopodite. In both these older stages the first maxilliped has considerably developed, consisting of a long cylindrical appendage borne on a short stump.

Thus it is evident that the *Phyllosoma* of *Palinurus vulgaris* reaches a length of more than 21 mm. before it begins to lose the characteristic flattened form of the larva. The smallest *Palinurus* observed by Richters was 25 mm., or 1 inch in length, and had all the characters of the adult. The later stages of transition between the *Phyllosoma* and the young *Palinurus* have still to be discovered.

I hoped to obtain stages later than those I have here described, but unfortunately the weather during the latter half of July and the whole of August was persistently stormy, and it was impossible to collect in the open sea. In September I resumed my expeditions, but obtained no more Phyllosomes.

DESCRIPTION OF PLATES VIII AND IX,

Illustrating Mr. Cunningham's paper "On the Development of *Palinurus vulgaris,* the Rock Lobster or Sea Crayfish."

PLATE VIII.

Fig. 1.—Newly hatched larva of *Palinurus vulgaris;* ventral surface, magnified 19 diameters. From a specimen hatched in the Aquarium, July, 1889.

PLATE IX.

Fig. 2.—*Phyllosoma* stage of *Palinurus vulgaris,* 7 mm. long, taken in large tow-net south of Eddystone, July 16th, 1891. The Roman figures in this and the preceding figure indicate the appendages (excluding the eye-stalks), numbered from the first antenna backwards.

Fig. 3.—The oral appendages of a larva 4·5 mm. long. *u. l.* Upper labium. *l. l.* Left half of lower labium. *md.* Mandible. 1 *mx.* First maxilla. 2 *mx.* Second maxilla. 1 *mxp.* First maxilliped.

Fig. 1.

J. T. Cunningham del. F. Huth Lith^r Edin^r

Fig. 2.

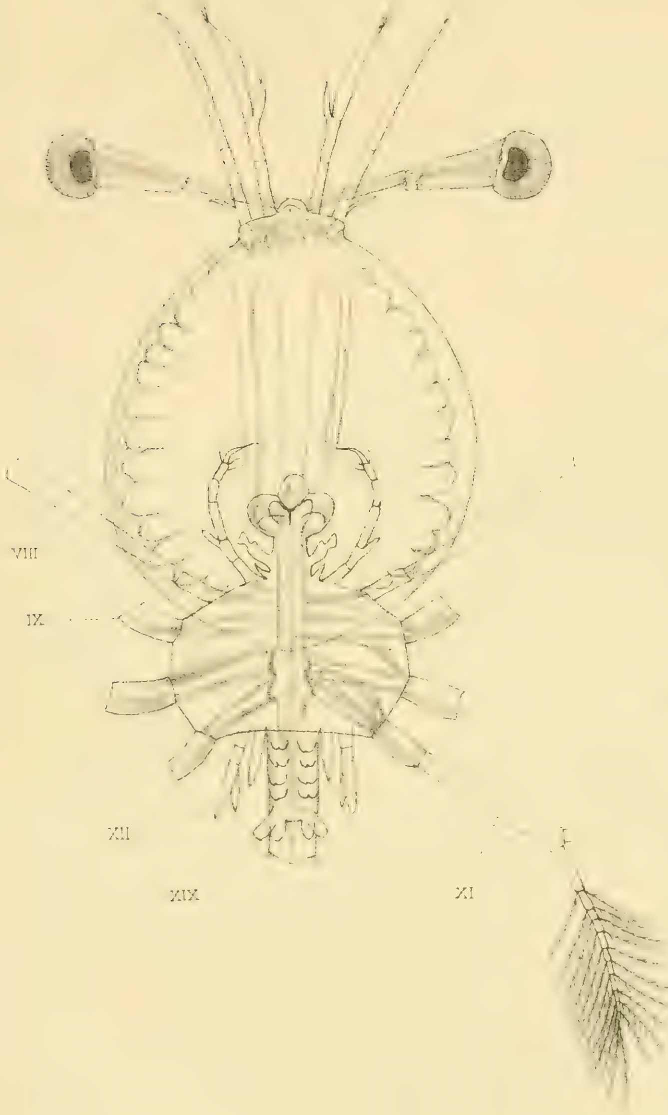
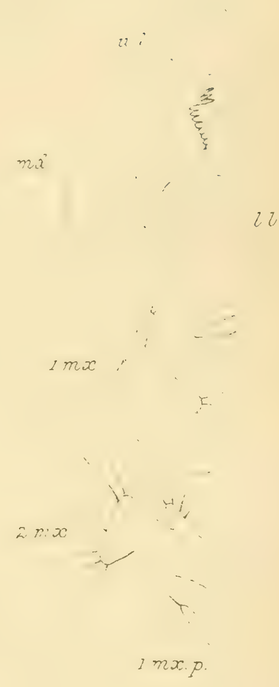


Fig. 3.



The Reproduction and Growth of the Pilchard.

By

J. T. Cunningham, M.A.

With Plate X.

In my paper on the *Reproduction of Fishes occurring at Plymouth,* published in this Journal, vol. i, p. 10, 1889, I identified as the egg of the pilchard, a pelagic egg commonly found in the tow-net in summer, and distinguished by three obvious characters, namely: (1) an unusually large perivitelline space; (2) a single large oil-globule in the vitellus; (3) a completely subdivided yolk. I also stated that ripe spawning pilchards occurred off Plymouth between June and October, but always at some distance from land, being usually taken in mackerel nets worked to the south of the Eddystone. My identification of the egg, taken in the sea, was founded upon a comparison between it and the eggs pressed from the ripe but dead female pilchards obtained from mackerel fishermen. The latter eggs were already dead, and did not float, but sank in sea water, but they possessed a single oil-globule, and the yolk in them consisted of a number of yolk-spheres. The large perivitelline space was absent, because it is only formed when living eggs are extruded into sea water.

Raffaele had previously described two kinds of pelagic eggs found at Naples, which he recognised, from their divided yolk and the characters of the larvæ hatched from them, as belonging to some species of Clupeoid. The larger of these eggs he attributed to *Clupea pilchardus,* but did not give his reasons. This egg is in all respects similar to that identified as belonging to the pilchard by myself at Plymouth. It is well known that the sardine of the French coast and of the Mediterranean is the same species of fish as the pilchard of Devon and Cornwall.

The natural history of the sardine has been investigated in recent years by two distinguished zoologists in France, namely, by Professor

G. Pouchet, who is Director of a marine laboratory at Concarneau, on the coast of Brittany, and by Professor Marion, who has a similar laboratory at Marseilles.

The first publication in which Pouchet mentions the mature egg of the sardine is a note in the *Comptes Rendus* of the French *Académie des Sciences,* tome cix, No. 3 (July 15th, 1889). He states there that the *sardine de rogue* is a young sardine which is not yet full grown, and which has not yet spawned; while the *sardine de dérive* is alone adult, and alone sometimes contains mature ova. The explanation of these French terms, applied to sardines of different sizes on the French coast, is as follows:—*Rogue* is the name given by the French fishermen to a preparation of cods' roe which they throw into the water as a bait to attract the sardines. After the bait is thrown overboard a seine is shot round the place, and the sardines thus enclosed. *Sardines de rogue* are thus sardines caught by means of rogue and seine. *Dérive,* on the other hand, means drift, and *sardines de dérive* are those caught in drift-nets.

Pouchet proceeds to briefly describe the ripe ova taken from large sardines. He says they measure 1·20 to 1·30 mm. in diameter; that they are transparent, heavier than sea water, and in the latter fall rapidly to the bottom. He says that there is little probability that the fertilized egg would behave differently, although some have supposed that it does. In any case, he says, he and his colleagues have never found this egg at the surface of the sea in the Bay of Concarneau. According to the same paper the vitelline membrane of the sardine's egg is smooth at its outer surface, but on its inner surface presents a reticulation of projecting ridges. The membrane consists of two layers, an external very thin and very refringent, and an internal thicker layer. The vitellus is granular and filled entirely with clear spheres, and with a single oil-globule of a pinkish colour. The paper concludes by insisting that the irregularity in the condition of the ovaries in the *sardines de rogue* indicates that the reproduction of the species is not subject to the influence of the seasons, but, like the greater part of the existence of the species, is carried in waters whose temperatures are nearly constant, that is in regions beyond the reach of man.

It is evident that, apart from the vitelline membrane, Pouchet does not differ from me as to the structure of the ripe egg of the pilchard; and as he has never seen the fertilized egg, it is somewhat hazardous on his part to argue that it does not float. The note above cited was published subsequently both to my paper and Raffaele's, so that it must be presumed that Pouchet attaches little weight to our evidence.

In his Report on the Concarneau Laboratory for 1889 presented to the French Minister of Public Instruction, and reprinted in the

Journal d'Anatomie et de Physiologie, December, 1890, Pouchet again discusses the history of the sardine. He refers to the note I have criticised above, saying that in it he made known for the first time the ripe egg of the sardine. The assertion is the more surprising because in a note on the same page he refers to my paper published in this Journal in March, 1889, four months before his own, and containing both a description and figure of the ripe ovum taken from the fish. In this foot-note Pouchet remarks that I made no reference to the structure of the vitelline membrane, which alone could justify an identification of the egg. He refers to a detailed description of the ripe ovarian egg by M. Biétrix, one of his assistants, printed as an appendix to the Report. But strange to say M. Biétrix does not confirm Pouchet's results as to the peculiarities of the vitelline membrane. He finds, it is true, that the membrane consists of two layers, but he states that the ridges on the internal face of the membrane are not always present, and when present are very variable in appearance; they are generally present when the egg is taken from the ovary and disappear a few minutes afterwards. M. Biétrix thinks that these markings are perhaps due to an alteration of the membrane, the eggs having only been examined in sardines captured several hours before, and in a bad state of preservation. It is evident, therefore, that no importance in respect to identification is to be attributed to the vitelline membrane of the egg of the sardine. On the other hand, M. Biétrix, like Pouchet himself, fully confirms my description of the yolk and the single oil-globule.

Pouchet's most recent utterance on this subject is a note in the Comptes Rendus, dated April 6th, 1891. He tells us there that he has only twice in three years been able to observe ripe female sardines ready to spawn, namely May 29th, 1888, and April 3rd, 1890. It is evident, therefore, that Pouchet has not had many opportunities for studying the subject, the reason probably being that there is no fishing at Concarneau capable of capturing adult sardines, and carried on at a sufficient distance from the shore.

Professor Marion, at Marseilles, has published his observations on the sardine in the Annales du Musée de Marseille, 1890 and 1891. He finds that adult sardines are present in the Gulf of Marseilles all the year round. The sexual organs show no signs of enlargement till the beginning of October, and ripe specimens are seen from December till March, while some shoals have not spawned till the beginning of May. This result is in harmony with mine, for it is not surprising that the sardine should spawn in winter and spring in the warm waters of the Mediterranean, while it spawns in summer at Plymouth, and in both regions it appears that the spawning

period is prolonged over five or six months, though the majority of the fish spawn within two months. Marion squeezed the ripe eggs from the fish into sea-water; the eggs on leaving the ovary were 1·3 to 1·4 mm. in diameter, but after being in the water some hours the great perivitelline space had been formed, and the eggs were 1·7 to 1·8 mm. in diameter, although they did not float. He remarks that this is no proof that eggs perfectly healthy, living and fertilized, do not float, while the vast perivitelline space establishes a great resemblance with the eggs attributed to the sardine, being a rare character in buoyant eggs. Marion also obtained in the Gulf floating eggs of the kind assigned by Raffaele and myself to the sardine, and found them only at the time of year when the sardines were ripe. Marion figures the egg and the larva hatched from it, pointing out that the latter is undoubtedly a clupeoid larva.

In the course of the past summer I made an attempt to finally set at rest the question of the pilchard egg by obtaining healthy fertilised ova from the parent fish by artificial fertilization. With this object I went out in a mackerel boat on June 21st, and on June 22nd the nets were shot about twenty miles to the south of the Eddystone, that is nearly thirty miles from the coast. When the nets were hauled I obtained in all about fifty ripe pilchards from them, but to my disappointment found there was not a single male among them. Probably the explanation of this is that the meshes of the net were rather large, and that the males are not quite so swollen when ripe as the females, and were, therefore, not retained. It must be pointed out that these ripe pilchards are not meshed by the gills in a mackerel net as the mackerels are, but are meshed round the abdomen, which is greatly distended by the swollen ovaries. Pilchard nets are never, so far as I know, used off Plymouth so far out at sea as spawning pilchards are found. In fact, very little pilchard fishing is carried on in June and July, and when it is recommenced in August and September it is carried on almost exclusively inside the Eddystone. (See Mr. Roach's records of pilchard fishing, this Journal, vol. i, p. 388.)

However, I squeezed some ripe eggs from the living female fish I obtained into a bottle of clean sea-water without delay, and when I examined them in the Laboratory a few hours afterwards I had the satisfaction of finding nearly all of them floating at the surface. These floating eggs were in all respects similar to the eggs identified as pilchard eggs obtained in the tow-net from the sea; they were perfectly transparent, the yolk in them consisted, not of yolk-spheres as in the dead ova from the ovary, but of polygonal masses, that is of yolk-spheres made polygonal by mutual pressure, as in the eggs obtained from the sea, the large oil-globule was present and the

great perivitelline space was formed. These eggs measured 1·2, 1·36, 1·45 mm. in diameter, that is, the perivitelline space was not quite so large as in fertilised eggs, but this is not surprising. The experiment proves conclusively that the ripe eggs of the pilchard, when pressed from the parent fish immediately it is captured, do actually float in sea water, become transparent, and develop a large perivitelline space.

Professor Pouchet makes an appeal to his Government to provide a suitable ship in order to discover where the sardine passes its existence when away from the coast, and reproduces its kind. He thinks the objects of the search would be found within 200 or 300 miles from the shore. He rejects the results of Marion's observations at Marseilles, because what is true for the sardine of the Mediterranean does not apply to the oceanic sardine. But, as Marion points out, the mode of reproduction of the sardine has been made known at Plymouth, and the conditions cannot be so very different a few miles off at Concarneau.

2. *Growth.*—The sardine of the Mediterranean is not so large as our pilchard or the sardine of the west coast of France—the oceanic sardine, as Pouchet aptly calls it. At Marseilles the adult sardines are 15 cm. to 18 cm. in length, or 6 to 7¼ inches. Pouchet finds that the *sardines de dérive* attain a maximum of 25 cm. or even a little more, that is they are from 9½ to 10 inches long. The ripe spawning pilchards which I obtained this summer did not vary much from 24 cm. or 9½ inches.

At Marseilles and Nice the alevins or fry of the sardine are captured for the market, as whitebait, the fry of the herring and sprat, are in England. The sardines remain and are captured in the Gulf of Marseilles during the whole of the first year of their life, and Marion finds from examination of specimens at various times of the year that they increase in length 1 cm. per month. The fishermen of Nice give special names to the successive stages in the development of the sardine, thus the young fish from 2 to 4 centimetres long without the silvery layer in the skin are called *poutino nudo,* while at a little larger size, 4 to 5 centimetres, when they have acquired the silvery livery they are called *poutino vestido.* When still larger they are called *Palailla* and *Sardinettes.* Marion concludes that poutines which are 3 or 4 cm. long (1·2—1·6 in.) in March grow to a length of 12 or 13 cm. (4·7—5·1 in.) by the following December. These fish were spawned in February, and by the following February according to Marion they are 14 or 15 cm. long, and therefore, it would be supposed, ready to spawn themselves. Professor Marion does not express any opinion on this point, but it would certainly appear from his conclusions as to the rate of growth that the

sardine at Marseilles begins to spawn when it is one year old, although it probably does not reach the maximum size of 18 cm. ($7\frac{1}{4}$ in.) till it is at least two years old.

At present we have scarcely any evidence as to the growth of the pilchard or oceanic sardine. Pouchet tells us that the smallest sardine he has hitherto obtained was 9·8 cm. in length or 3·9 inches, and he thinks this was about six months old. At Plymouth I have not yet obtained the young of the pilchard at various successive stages. Our fishermen never seem to catch pilchards so small, and, therefore, presumably, so young as the fish taken for the sardine industry on the French coast. I believe this difference is due chiefly to the character of the nets used, the drift-nets at Plymouth having too large a mesh to retain the young fish. However I believe I have obtained some of the very early stages of the young pilchard. The specimens I refer to were taken in the same hauls of the large tow-net as the Phyllosoma I have described in another paper, that is to say they were obtained at the surface on July 9th and July 16th, about two miles north and south of the Eddystone. I have figured three of these specimens illustrating different stages of development. The smallest and youngest stage represented in fig. 1 is 8·5 mm. in length; the larval membranous fin is still present along the dorsal edge and behind the anus ventrally, the permanent dorsal fin is beginning to develope and a symmetrical larval tail fin is present supported by slender rays. All the figures have been drawn from preserved specimens mounted in Canada balsam, and this is the reason of their somewhat rough character, the mounted specimens having lost the transparency and sharpness of detail seen in living fish-larvæ. The notochord in the stage shown in fig. 1 is a large and conspicuous structure. Fig. 2 represents a slightly more advanced stage in which the development of the fin-rays of the dorsal fin is more pronounced, and there is an indication of the permanent caudal fin-rays on the ventral side of the notochord in the tail. The actual size of the specimen from which this figure was drawn is 11·5 mm. The specimen represented in fig. 3 is 2·4 cm. long, and is in the same stage as the fish called at Nice *poutino nudo*. All trace of the primordial fin-membrane has disappeared, and the permanent fin-rays are almost completely developed in the dorsal fin, ventral fin, and caudal fin. The pelvic fins have also appeared; the pectorals are present in the earlier stages, but in this stage are larger, and their fin-rays are beginning to develop. The dorsal fin at this stage is some distance behind the pelvic, while in the adult its anterior extremity is in front of the pelvic.

That these young clupeoids are not herring larvæ is proved by

Plate X.

Fig. 1.

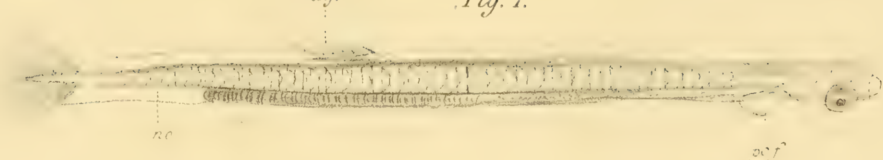


Fig. 3.

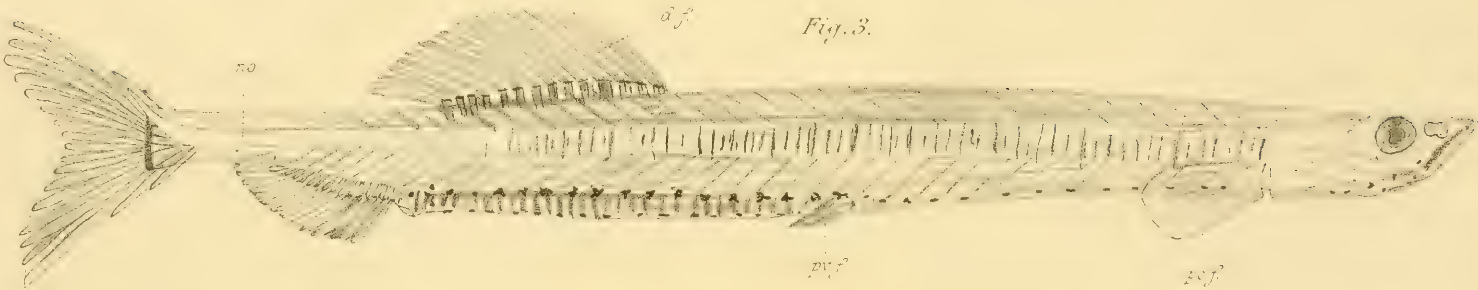


Fig. 2.

J T Cunningham del.

two facts, first that the herring at Plymouth spawns in January, and second that the herring larva is 9 mm. long, larger than the earliest stage above described, even before the yolk-sac is absorbed. But it is more difficult to prove that they cannot be sprat larvæ. Sprat eggs occur most plentifully in the tow-net gatherings in January, February, and March, and I have taken only solitary specimens as late as the beginning of May. On the other hand pilchard ova were plentiful in tow-net gatherings taken outside the Eddystone in June, and the earlier stages above described are certainly not more than a fortnight or three weeks old, while the oldest stage is probably four or five weeks.

DESCRIPTION OF PLATE X,

Illustrating Mr. Cunningham's paper on "The Reproduction and Growth of the Pilchard."

d.f. Dorsal fin. *no.* Notochord. *pc.f.* Pectoral fin. *pv.f.* Pelvic fin.

FIG. 1.—Larva, probably of pilchard, 8·5 mm. long.

FIG. 2.—Older larva, 11·5 mm. long.

FIG. 3.—Later stage, 2·4 cm. long.

The Distribution of Crystallogobius Nilssonii.

By

J. T. Cunningham, M.A.

When trawling with a small beam trawl on July 9th last, a couple of miles north of the Eddystone, I obtained a large number of specimens of a fish which was quite unfamiliar to me. I found it was *Crystallogobius Nilssonii*. The chief characters distinguishing the species are the presence of only two rays in the anterior dorsal fin of the male, and the almost complete absence of this fin and of the pelvic fins in the female. The adult male is 4·4 cm. long, the female about 3 cm. When alive the fish is very translucent, and it is entirely destitute of scales. The species was first described by Düben and Koren in 1844 from half a dozen specimens taken near Bergen. Robert Collett has well described it in the Proceedings of the Zoological Society for 1878, having taken twenty-eight specimens at about 30 fathoms in the Christiania Fjord in the years 1875—1877. Only forty-five specimens altogether had been taken off the south and west coast of Norway at the time when Collett wrote. I captured 201 specimens in a single haul of the trawl, 188 of which were female and 13 male. Nearly all were adult, the eggs being visible through the integuments in the female. A few not quite full grown are included among the 188 reckoned as female, and some of these may prove on closer examination to be young males. In any case the excess of females is very great.

The species has already been included in the British fauna by Day, a single specimen having been taken by Edward in a rock pool at Banff. After I had identified my specimens, I received a copy of a paper by Mr. E. W. L. Holt (Proc. Roy. Dublin Soc., February, 1891), announcing that he obtained many specimens of the same species in Ballinskelligs Bay at a depth of 30 fathoms on the 21st August, 1890. It is evident, therefore, that the species, hitherto supposed to belong chiefly to Scandinavia, is common enough in certain localities on the British and Irish coast. The depth where my specimens were obtained was about 28 fathoms, the bottom, sand. The shrimp-trawl I was using was lined with mosquito-netting for the express purpose of catching small and young fish.

Physical Investigations.

PRELIMINARY PAPER.

By

H. N. Dickson, F.R.S.E.

With Plate XI.

It may be taken for granted that, apart from its purely scientific value, a knowledge of the physical conditions affecting the waters of the sea has been shown to throw considerable light on many important economical questions. In its bearing on fish and fisheries, the inquiry may be said to have reached a point where it is conclusively shown that there is a problem to solve.

In a report of the Herring Committee of the Scottish Meteorological Society we find the following stated as preliminary results:—"If, during the herring season, there be a district where, from any cause, the temperature of the sea is lower than in surrounding districts, the catch of herrings is heavier in that district; and conversely if there be a district where, from any cause, the temperature of the sea is higher than in surrounding districts, in that district the catch of herrings is less. Among the causes which bring about a local increase or decrease of sea temperature, the chief are clouded or clear skies in respective districts, according as these occur during the day or during the night. . . .

"The above refers to local fluctuations of temperature during the fishing season, when the temperature of the sea is high. It appears from the observations of past years that the herring seasons have closed about the time when the temperature of the sea in its annual fall has fallen generally to 54·5° F. It is of importance to ascertain how far this relation exists from year to year and in different districts.

"Another important point is the relation of surface temperature to bottom temperature, and the relations of the deepest parts of the sea to the positions of the fishing-grounds. It is found, for instance, that when the surface temperature is high—higher than lower down—the fish, if any can be caught, strike the nets far

down in such a way as to lead to the supposition that a good deal of failure may often arise from the nets not going deep enough. The fish prefer, apparently, so far as the inquiry has gone, the lower to the higher temperature."*

Again, in summarising the results of physical investigations carried out for the Fishery Board for Scotland, Dr. John Gibson says, "I am not sure that the observations already made do not even now point to a connection between the presence of Atlantic water in the Moray Firth as a condition of successful inshore herring fishing. In the summer of 1883, when surface Atlantic water filled the Moray Firth, the inshore herring fishings in this firth are reported to have been unusually productive; while, on the other hand, in the summer of 1886, when water from the bottom of the North Sea filled the firth, during the month of August at any rate, it is reported that more than one half of the entire season's catch in the inshore waters was made during one single week, and that all the rest of the season these inshore waters were comparatively unproductive."†

That this opinion is general is shown by the extensive physical investigations carried on by the German Government, both by means of coast stations and exploring expeditions, such as those of the "Pommerania"‡ and the "Drache,"§ by the Norwegian Government, and by the U.S. Commission of Fish and Fisheries, the last named being about to publish an extensive series of observations of temperature and density on the Atlantic seaboard.

So far, however, the problem has only been stated; it has been shown that a more or less indirect relation exists between the physical and meteorological conditions affecting any particular region of the sea, and the quantity and quality of the fish to be caught in that region. Further, it has been shown that two methods of investigation give the most promising results:—(1) Continuous observations of temperature at fixed stations extending over a considerable period of time; and (2) Expeditions making a rapid survey of a certain area at intervals; the distribution of temperature being observed, and samples of water collected for subsequent examination.

These facts ascertained and defined, it remains at present to increase as far as possible, in either or both of the above-mentioned directions, the material for discussion.

In organising, at the request of the Director, a section for physical

* Journ. Scott. Met. Soc., 1876, vol. v, p. 30.

† Report of the Fishery Board for Scotland, 1888, p. 471.

‡ Jahresbericht der Commission zu Wissenschaftlichen Untersuchung der deutschen Meere in Kiel, 1872-3, Berlin, 1875.

§ Ergebnisse der Untersuchungsfahrten der Drache, Berlin, 1886.

work under the auspices of the Association, I have been chiefly guided by these considerations, and the work has divided itself into two separate investigations:—(1) The collection and discussion of existing observations, especially those of surface temperature; and (2) An inquiry into the physical conditions obtaining in the English Channel generally, and specially in the local fishing-grounds, by observations of temperature, examination of water samples, &c.

Through the kindness of the Meteorological Council, access has been obtained to all the records of surface temperature stored in the Meteorological Office. Part of the material has already been handed over to me, and a beginning has been made with its reduction and discussion. This work is necessarily laborious, and some time must elapse before any results can be presented for publication.

The difficulties in the way of commencing practical work were considerable. The steam launch belonging to the Association is useless for sounding outside the harbour except under unusually favourable conditions. I accordingly made an application to the Government Grant Committee of the Royal Society for the sum of £100, to pay hires of steam tugs for trips across the Channel at intervals. This application was granted. The unusually bad weather of the past summer, and the comparatively small amount of time at my disposal for research, have unfortunately prevented more than one trip being made, the results of which are given below.

The methods of marine physical investigation are now sufficiently well known to make it unnecessary to describe in detail the instruments and apparatus used. Temperature observations are made with Negretti and Zambra's reversing thermometer, in the Scottish frame,* and samples collected by Mill's self-locking water-bottle.† Where surface observations only are made, a sample of water is obtained in a wooden bucket, the temperature being taken by means of an ordinary thermometer, and the sample transferred to a glass bottle. All thermometers used have been verified by repeated comparison with a Kew standard belonging to the Association, and in most cases the instruments have Kew certificates in addition. Every care has been taken throughout to keep the errors of temperature observations within 0·1° F.

As the samples collected are at once brought to the Laboratory and their examination proceeded with, it has not been thought necessary to take special precautions in sealing the bottles. Winchester quarts of the ordinary type are used, note being made that the stoppers are well ground in each case.

Determinations of density have been made in the first place with

* Proc. Roy. Soc. Edin., xii, p. 928.

† Mill, ibid., 1886, vol. xiii, pp. 539—546.

an hydrometer of the "Challenger"* type, kindly presented to the Association by J. Y. Buchanan, Esq., F.R.S. This instrument weighs *in vacuo* 150·6897 grammes, and is furnished with seven brass weights varying from 0·3102 gr. to 4·0100 gr., giving for each sample of water at any temperature at least two distinct determinations. The constants of the instrument have been carefully determined twice at temperatures varying from 5° C. to 30° C., and the maximum probable error has been found to be 0·00005, a result agreeing with that arrived at by Mill.†

The want of a sufficiently delicate and reliable balance made the further examination of samples at first almost impossible. Through the kindness of Messrs. Balkwill, chemists, Plymouth, we now have access to an instrument giving results reliable to 0·1 mgrm.; and recently Prof. A. M. Worthington, of the Naval Engineering College, Devonport, has lent to the Laboratory a balance capable of weighing 100 gr. to within 1·0 mgrm. While we are unable to carry out analyses with the high precision reached, for example, in Dr. Gibson's work for the Scottish Fishery Board, we may now hope to make determinations sufficiently accurate to be of considerable value. The first object aimed at is to obtain determinations of density by means of the modified form of Sprengel's pyknometer.‡ In the hydrometer determinations given, the densities are reduced to 15·56° C. compared with distilled water at its maximum density point by Dittmar's tables.§ These tables, however, can only be safely used where the sample approaches the standard density of 1·02600 at 15·56° C. In all other cases determinations made with Sprengel tubes filled in melting ice are much to be preferred.

In the more strictly chemical work I have had the advantage of the co-operation of Mr. F. Hughes, the Chemist of the Association. The alkalinities of all the samples already collected have been determined by the usual methods with a fair degree of accuracy, and considerable progress has been made with estimation of the amounts of chlorine. I have thought it best to defer publication of the chlorine results until more progress has been made with the densities.

Table I gives the results of observations made in a trip on ss. "Deerhound" in the Channel in June last. On June 15th a line was taken from Bolt Head to a point west of Hanois Light, and thence to St. Peter's Port, Guernsey; on June 16th from Guernsey to St. Catherine's in the Isle of Wight; and on June 17th

* Challenger Reports, Narrative, vol. ii, pt. 2.

† Proc. Roy. Soc. Edin., xiii, p. 35.

‡ Report of the Fishery Board for Scotland, 1887, p. 336.

§ Challenger Reports, Physics and Chemistry, vol. i, p. 70.

from Anvil Point back to Bolt Head (see Plate XI). Column 1 gives the laboratory number of each sample of water; columns 2 and 3, the date and hour; columns 4 and 5, the position and depth of the sounding; column 6, state of the tide; 7 and 8, direction and force of the wind; 9, weather at the time of observation; 10, temperature of the air as ascertained by a sling thermometer; 11, depth of observation; 12, the temperature (corrected) at that depth; 13 and 14, the densities, referred to 4° C., at 15·56° C., and *in situ*. Column 15 shows the density at 0° C. referred to distilled water at 0° C., as determined by the Sprengel tubes; and column 16 the alkalinity.

The values given in column 13 are the means of at least three double determinations, and may be taken as accurate to $\pm$ 3 in the fifth place of decimals. The reductions, as before stated, have all been effected by means of Dittmar's tables; and as the deviations from standard water are in most cases very small, it is improbable that additional error has been introduced.

The numbers in column 15 are the means of at least two determinations in each case, and may be taken as correct within $\pm$ 2 in the fifth place.

The alkalinities have in great part been estimated twice, and are subject to an actual error not exceeding unity, the relative error being probably considerably less.

Table II gives extra observations of surface temperature, taken at intervals of about half an hour. The positions are given with reference to the sounding stations I, II, III, &c., as in Table I.

The route followed in the trips under consideration was chosen simply with the view of finding the most promising fields of investigation. I hope under more favourable conditions to repeat the observations in various parts of the Channel at intervals of two or three months. If this could be done regularly for several seasons we cannot doubt that a good deal of light would be thrown on variations of climate on different parts of our coasts, as well as on the distribution of fish at different periods.

Any general discussion of the observations made in June last is of course useless until material for comparison has been obtained, but a few noticeable features may be pointed out. It appears in the first place that the water in the area surveyed is extremely uniform. The densities at 15·56° C. show but little variation, the highest values, 1·02618 and 1·02612 at surface, and 1·02625 and 1·02612 at bottom, occurring at stations IIa and VIII; and the lowest, 1·02588 at surface and 1·02582 at bottom, at station X, off St. Catherine's. The mean density is practically that of normal sea water, both at surface and bottom, except off St. Catherine's.

The alkalinities also show great uniformity, varying only between

51 and 53, and the surface and bottom samples for each station showing no marked differences. The highest values are found for samples taken down Channel and on the southern side, a decrease being observed in Start Bay and along the coast to the eastwards.

At a depth of 10 fathoms a distribution of temperature is found which remains practically unaltered at all stations until the bottom is reached; even in the case of station VII the temperature at 73 fathoms is only 0·2° F. lower than that at 10 fathoms. At these depths the highest temperatures are found off the English coast east of the Bill of Portland, and again in the neighbourhood of the Channel Islands, colder water occurring in mid-Channel at stations II, IIa, and III, and VII and VIII, and between Start Point and the Bill of Portland, where the minimum of 50·6° F. is reached, the isothermals curving into Start Bay and turning south again.

On the surface the distribution of temperature is peculiar; and although the observations here are very much more numerous, less weight can be attached to their results on account of the action of wind. It is to be noted that on the first day of the cruise the wind was south-westerly, light, freshening, and veering a little towards evening, till at 2 a.m. next morning it was blowing hard from about west. After daybreak the force greatly diminished, and the wind gradually veered to north-west and died away altogether. On the third day the wind was westerly and extremely light, dying away to a calm at times.

Wherever undisturbed by land influences, the line between stations I and IV may be said to show a uniform temperature at the surface of 53·7° F. Further up Channel, *i. e.* between stations VI, VII, VIII, and IX, a lower temperature is found, varying irregularly at the time of observation between 52° F. and 53° F.; and this colder surface water seems to extend at any rate round the island of Guernsey. In the area covered by stations IX, X, XI, and XII a temperature between 53° F. and 54° F. is found, rising as we approach Poole Bay to about 55° F.

In the region between Start Point and the Bill of Portland a totally different distribution occurs. We find here the highest temperatures of the whole cruise, rising suddenly 2° as the Bill of Portland is passed, and slowly increasing thereafter till the maximum of 57° F. is reached off Beer Head. A sudden drop to below 52° is observed over the Skerries off Dartmouth Harbour. Soundings XIII and XIV show that the layer of warmer water is quite superficial, the temperature falling to 51·9° F. at 6 fathoms in XIII, and to 50·9° F. at 8 fathoms in XIV. It may be noted that extra samples, No. 42 and No. 45, show no change in the density at 15·56°. With regard to column 14, densities *in situ*, we have of course simply the results of the distribution of temperature, with the small variations of

column 13. On the bottom the highest values are obtained in mid-Channel and in Start Bay, decreasing slightly on the southern coast, and more markedly to the east of the Bill of Portland. On the surface, again, the highest values are found at stations IIa and VIII, and on the southern side; and the lowest off the English coast, those to the east of the Bill of Portland being due to differences in the water, those to the west to differences of temperature.

The results suggested by these observations may be summarised as follows :

(1) The waters of the Channel are subject to a peculiar circulation, the nature of which cannot be determined without more extended investigation.

(2) The distribution of temperature in Start Bay demands special investigation. In this area we find the highest surface temperatures and the lowest bottom temperatures, the warm surface layer being about 6 fathoms in thickness, while at the same time there is no change in the composition of the water. In Start Bay we have a notedly good trawling-ground, and this confirms the result obtained off the east coast of Scotland by Dr. Gibson as already quoted, and again by myself,* viz. that where we have true oceanic waters, unmixed with estuarine or river waters, subject to special temperature conditions due to the presence of land or other causes, we find favourable conditions for successful fishing. This result seems to be to some extent borne out by observations on the Dogger Bank fishing-grounds.

What these temperature conditions actually are must be shown by investigation. The preliminary trip in the Channel indicates that more numerous and detailed temperature observations must be made over a large area, and that the samples collected need not be so numerous, but must in all cases be subjected to a rigorous examination of the greatest attainable accuracy.

In conclusion, I may say that the material discussed in my paper already quoted seems to me exceptionally valuable in the inquiry in hand. Observations of surface temperature taken regularly *on the fishing-grounds* by fishermen afford data of extreme interest even when great accuracy is not attempted. I have tried to initiate such observations amongst the local fishermen on these coasts, so far, unfortunately, without much success. The Association will be glad to supply instruments and books to any fisherman or seaman on any part of the coast who will take such observations.

During the winter months I hope also to investigate the conditions of local estuarine waters in relation to fisheries.

* Journ. Scott. Met. Soc.,' 1889, vol. viii, No. 6, p. 332.

Table I.

No. of sample.	Date.	Hour.	Position.	Depth. Fath.	Tide.	Wind. Direction.	Wind. Force.	Weather	Temp. of air.	Depth of observation	Temp. of sea. T.	S. 4. 15·56.	S. 4. T.	S. o. o.	Alkalinity.
13	12/6/91	Noon	Eddystone, S.W. 7 miles	28	½ ebb	S.W.	0	*b*	...	0	53·8	1·02607	1·02679	...	53·4
										1½	52·0				
										5	51·1				
										10	51·0				
										15	50·7				
										20	50·7				
14	...	...	...	...	...	...	...	...	...	27	50·6	1·02620	1·02725	...	53·1
15	12/6/91	1.30 p.m.	Between Penlee Point and Mewstone	10	½ ebb	...	...	...	...	0	54·0	1·02551	1·02621	...	52·0
										5	51·5				
16	...	...	...	...	...	...	...	...	...	9	50·9	1·02599	1·02700	1.02829	52·2
17	15/6/91	9 a.m.	I. Bolt Head, N.E. × E. 1½ miles	20	½ fl.	W.S.W.	0—1	*f°*	55	0	52·6	1·02601	1·02686	1·02820	52·8
										5	51·8				
										8	51·5				
										10	51·8				
										13	51·6				
										15	51·4				
										17	51·6				
18	...	...	...	...	...	...	...	...	...	19	51·4	1·02599	1·02695	...	52·2
19	15/6/91	12.30 p.m.	II. S.E. × S. ¼ S., 20 miles from I	40	H. W.	W.S.W.	1	o	56	0	53·9	1·02606	1·02676	...	53·0
										5	53·4				
										7	52·9				
										10	51·1				
										15	50·9				
										20	51·0				
20	...	...	...	...	...	...	...	...	...	39	50·9	1·02616	1·02717	...	52·8
21	15/6/91	2.30 p.m.	IIa. S.E. × S. ¼ S., 16 miles from II	42	½ ebb	...	...	...	56	0	53·8	1·02618	1·02690	1·02856	51·6
										22	51·4				

22	...	...	...	...	...	...	...	...	...	41	51·2	1·02625	1·02723	...	52·4
	15/6/91	3 p.m.	III. S.E. × S. ¼ S., 18 miles from II	40	...	...	...	...	55	0	53·8				
										5	53·1				
										10	51·5				
										12	51·4				
										15	51·3				
										20	51·3				
										39	51·2				
23	15/6/91	6 p.m.	IV. S.S.E. ½ S., 23½ miles from III. Hanois E.N.E. 3 miles	32	L.W.	W.S.W.	0—1	∞	55	0	52·6	1·02603	1·02688	...	52·2
										5	52·2				
										10	52·0				
										15	51·9				
										22	51·9				
24	...	...	...	...	...	...	...	...	...	31	51·9	1·02611	1·02702	...	52·5
25	15/6/91	7.25 p.m.	V. St. Martin's Point N.E. 2 miles	30	½ fl.	W.S.W.	0—1	f^{∞}	...	0	52·2	1·02608	1·02697	...	52·4
										10	52·0				
										15	51·9				
										20	51·9				
26	...	...	...	...	...	...	...	...	...	29	51·8	1·02601	1·02693	...	52·0
27	16/6/91	8.30 a.m.	VI. Caskets N.W. ½ N. 9 miles	28	1 hr. fl.	N.N.W.	1	∞	...	0	53·2	1·02604	1·02682	...	52·1
										5	53·0				
										10	52·8				
										15	52·7				
										20	52·4				
										23	52·4				
28	...	...	...	...	...	...	...	...	...	27	52·2	1·02606	1·02695	...	52·2
29	16/6/91	12.30 p.m.	VII. Caskets S.W. × S. 9 miles	73	H. W.	N.W.	1	Cloud-less	...	0	53·6	1·02607	1·02681	...	52·2
										5	51·9				
										10	51·6				
										20	51·4				
										30	51·3				
										40	51·3				
										53	52·0				
										60	51·9				
30	...	...	...	...	...	...	...	...	...	72	51·4	1·02609	1·02705	...	52·6

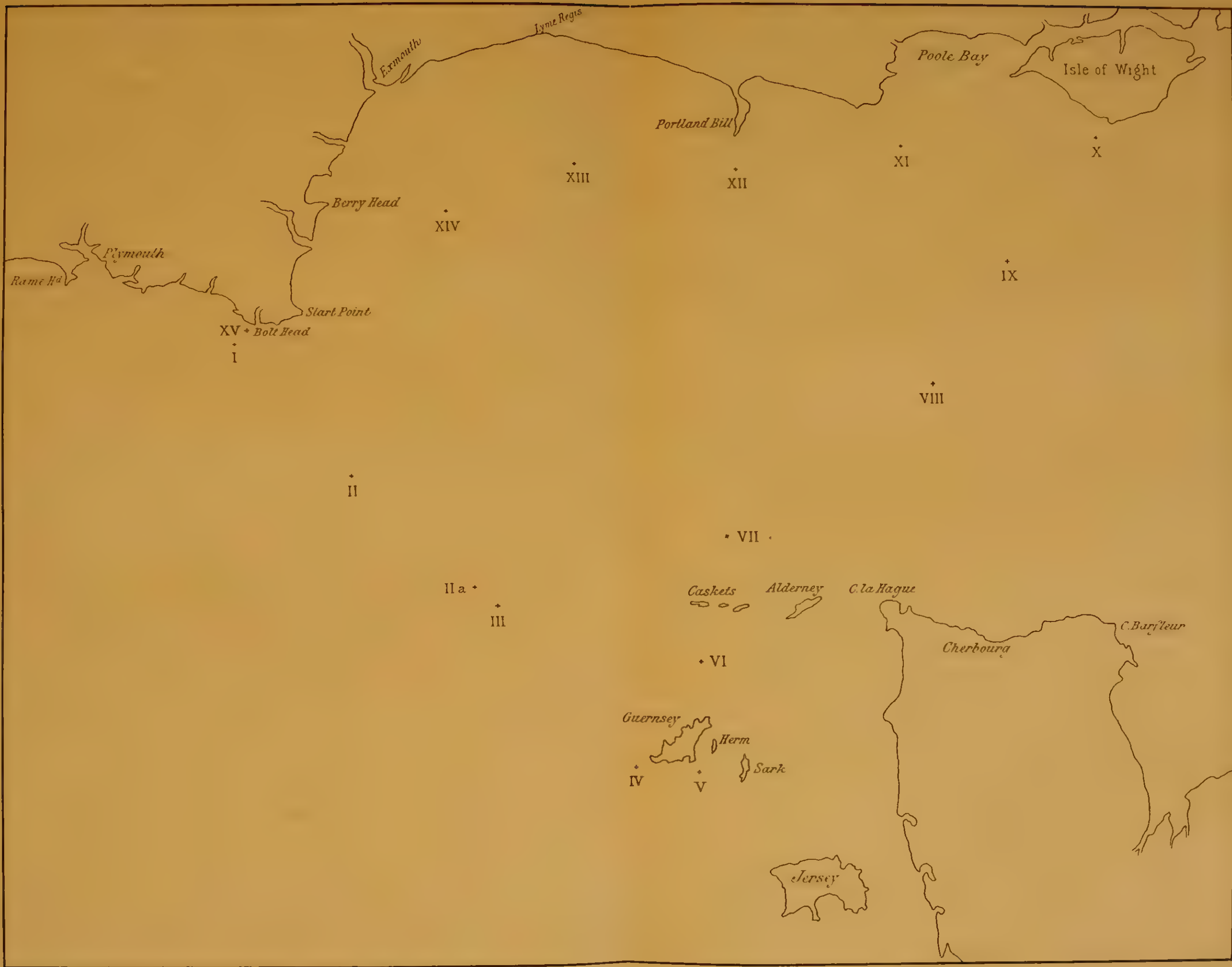
TABLE I (*continued*).

No. of sample.	Date.	Hour.	Position.	Depth. Fath.	Tide.	Wind. Direction.	Wind. Force.	Weather	Temp. of air.	Depth of observation	Temp. of sea. T.	S. 4. 15·56.	S. 4. T.	S. o. o.	Alkalinity.
31	16/6/91	4.15 p.m.	VIII. E. × N., 29 miles from VII	40	1 hr. ebb	N.W.	1	∞	...	0	52·0	1·02612	1·02703	...	52·2
										5	51·8				
										10	51·6				
										20	51·4				
										30	51·4				
32	...	...	...	...	...	...	...	...	...	39	51·3	1·02612	1·02710	...	51·5
33	16/6/91	6.15 p.m.	IX. N.E. × E., 15 miles from VIII	29	2 hr. ebb	N.W.	1	b	...	0	53·0	1·02604	1·02684	...	50·8
										5	52·9				
										10	52·8				
										19	52·8				
34	...	...	...	...	...	...	...	...	...	28	52·7	1·02599	1·02682	...	50·8
35	16/6/91	8.15 p.m.	X. St. Catherine's N.E. ¼ E. 2 miles	30	½ ebb	W.N.W.	1	b	...	0	54·6	1·02588	1·02650	...	51·1
										5	54·5				
										10	54·3				
										20	54·4				
36	...	...	...	...	...	...	...	...	...	29	54·3	1·02582	1·02648	...	51·1
37	17/6/91	6.45 a.m.	XI. Anvil Point N. × W. 10 miles	22	¾ ebb	Var.	0	b	...	0	53·7	1·02604	1·02676	...	51·1
										5	53·3				
										12	53·4				
38	...	...	...	...	...	...	...	...	...	21	53·3	1·02602	1·02680	...	51·9
39	17/6/91	10 a.m.	XII. Portland Low Light N.N.E.	29	¼ fl.	Westerly	0	b	56	0	54·3	1·02606	1·02672	...	52·0
										2	53·2				
										5	53·5				
										10	53·1				
										19	53·1				
40	...	...	...	...	...	...	...	...	...	28	53·0	1·02602	1·02682	...	51·2

41	17/6/91	Noon	XIII. Beer Head N. × E. 18 miles	28	¾ fl.	W.S.W.	0—1	o	57	0	55·9	1·02611	1·02659	...	51·9
										2½	55·0				
										5	52·9				
										6	51·9				
42	...	...	...	...	...	...	...	...	...	8	51·5	1·02608	1·02704	...	51·1
										10	51·4				
										20	51·0				
43	...	...	...	...	...	...	...	...	...	27	51·0	1·02611	1·02710	...	51·0
44	17/6/91	2.15 p.m.	XIV. W.S.W. 14 miles from XIII	26	H. W.	W.S.W.	0—1	o	...	0	56·6	1·02608	1·02648	...	52·1
										3	56·3				
										5	55·2				
										6	51·9				
45	...	...	...	...	...	...	...	...	...	7	...	1·02608	1·02709	...	52·0
										8	50·9				
										10	50·9				
										15	50·6				
										20	50·6				
46	...	...	...	...	...	...	...	...	...	25	50·6	1·02608	1·02713	...	51·7
47	17/6/91	6.10 p.m.	XV. Bolt Head N.N.E. 1½ miles	20	¾ ebb	Calm	0	o	...	0	53·5	1·02598	1·02674	...	52·3
										1	52·5				
										2	52·5				
										5	52·2				
										10	52·0				
48	...	...	...	...	...	...	...	...	...	19	51·9	1·02602	1·02693	...	52·7

TABLE II.—*Surface Temperatures.*

Date.	Hour.	Position.	Temperature.
15/6/91	9 a.m.	I. Bolt Head N.E. × E. ....1½ miles	52·6°
	10	*a.* S.E. × S. ¼ S. from I......... 4 ,,	54·2
	10.30	*b.* ,, ,, ... 9 ,,	54·1
	11	*c.* ,, ,, ...13 ,,	53·5
	11.30	*d.* ,, ,, ...18 ,,	53·0
	12.30 p.m.	II. ,, ,, ...20 ,,	53·9
	1.20	*a.* S.E. × S. ¼ S. from II ...... 5 ,,	53·6
	1.50	*b.* ,, ,, ... 9 ,,	53·6
	2.20	*c.* ,, ,, ...14 ,,	53·7
	2.30	II. *a.* ,, ,, ...16 ,,	53·8
	3	III. ,, ,, ...18 ,,	53·8
	4	*a.* S.S.E. ½ S. from III......... 4 ,,	53·4
	4.30	*b.* ,, ,, ... 9 ,,	53·7
	5	*c.* ,, ,, ...14 ,,	53·7
	5.30	*d.* ,, ,, ...18 ,,	53·1
	6	IV. ,, ,, ...23½ ,,	52·6
	7	Pleinmont Point N.W. × N. ...... 4 ,,	52·2
	7.25	V. St. Martin's Point N.E............. 2 ,,	52·2
16/6/91	8.30 a.m.	VI. Caskets N.W. ½ N.................. 9 ,,	53·2
	9.30	*a.* ,, ,, ... 6 ,,	53·0
	10	*b.* ,, ,, ... 3 ,,	52·1
	10.30	Off the Caskets	52·2
	11	Caskets S.W. × S. .... 4 ,,	52·0
	12.30 p.m.	VII. ,, ,, ... 9 ,,	53·6
	1.50	*a.* E. × N. from VII .... 4 ,,	53·1
	2.20	*b.* ,, ,, ... 9 ,,	52.6
	2.50	*c.* ,, ,, ...14 ,,	52·6
	3.20	*d.* ,, ,, ...19 ,,	52·3
	3.50	*e.* ,, ,, ...24 ,,	52·3
	4.15	VIII. ,, ,, ...29 ,,	52·0
	5.50	*a.* N.E. × E. from VIII......... 9 ,,	52·2
	6.15	IX. ,, ,, ...15 ,,	53·0
	7.15	*a.* ,, from IX............ 4 ,,	53·9
	7.45	*b.* ,, ,, ... 9 ,,	54·5
	8.15	X. St. Catherine's Light N.E. ¼ E... 2 ,,	54·6
	9	S.W. off Brixton...................... 4 ,,	54·8
17/6/91	6.15 a.m.	Anvil Point N. × W. .... 6 ,,	55·6
	6.45	XI. ,, ,, ...10 ,,	53·7
	7.30	*a.* W. ½ N. from XI .... 4 ,,	53·9
	8	*b.* ,, ,, ... 9 ,,	53·7
	8.30	*c.* ,, ,, ...14 ,,	53·8
	9	*d.* ,, ,, ...18 ,,	54·1
	9.20	*e.* ,, ,, ...20 ,,	53·9
	10	XII. Portland Light N.N.E. .... 9 ,,	54·3
	10.30	*a.* N.W. × W. from XII......... 5 ,,	54·0
	11	*b.* ,, ,, ... 9 ,,	55·8
	11.30	*c.* ,, ,, ...13 ,,	55·5
	12 noon	XIII. Beer Head N. × E. ....18 ,,	55·9
	1 p.m.	*a.* W. ½ N. from XIII .... 4 ,,	56·3
	1.30	*b.* ,, ,, ... 9 ,,	56·2
	2.15	XIV. Berry Head W.N.W. ½ N.........11 ,,	56·6
	3.15	*a.* W.N.W. ½ W. from XIV... 5 ,,	57·4
	3.50	*b.* Off Berry Head...............	57·1
	4.20	*c.* Off Dartmouth	54·1
	4.50	*d.* Off Beeson......................	52·6
	5	*e.* Start Point W. ¾ S. .... ¼ mile	54·0
	5.10	*f.* ,, N.E. × E. ...... ¼ ,,	52·4
	6.10	XV. Bolt Head N.N.E. ....1½ miles	53·5



F. Huth, Lithr Edinr

Notes on Meteorological Observations at Plymouth.

By

H. N. Dickson, F.R.S.E.

The meteorological observations at Plymouth Navigation School, carried on for a period of more than twenty-six years by Dr. J. Merrifield, ceased on his death in June last. It seemed desirable that Plymouth should not be without an observing station, and as the Association was undertaking other work of a similar nature it was decided to begin observations on the scale of a station of the second order.

Mr. W. V. Merrifield, into whose hands the instruments passed on his father's death, kindly offered to lend a set of thermometers and sunshine recorder. The barometer used by Dr. Merrifield is the property of the Meteorological Council, who have transferred the instrument temporarily to the hands of the Association until another instrument can be acquired.

The ground behind the Laboratory, being almost enclosed by the walls of the Citadel, was obviously unsuitable for the exposure of meteorological instruments. Application was accordingly made to the municipal authorities of Plymouth for permission to erect a thermometer screen and to expose a rain gauge on the enclosed ground behind the public lavatory on the Hoe. This permission was granted by the Hoe Committee, and an exceptionally good exposure has been obtained close to the Laboratory.

In order to make the observations as generally useful as possible, copies are regularly supplied to the following :—(1) The Meteorological Office, weekly and monthly Reports. (2) The Royal Meteorological Society, monthly Reports. (3) The Medical Officer of Health, fortnightly Reports. (4) Western Morning News, daily Report and monthly Summary.

The sheets are issued from the Laboratory with all corrections made, and summed and averaged. The following is a list of the elements observed and calculated :—Atmospheric pressure. Temperature : Dry bulb, Wet bulb, Maximum, Minimum, Dew-point. —Pressure of vapour—Relative humidity. Wind : Direction, Force

(Beaufort Scale). Cloud: Form, Amount (0—10). Rainfall. Sunshine. Ozone (0—10).

The barometer is of marine pattern (B. T. 59), reading to ·002 in., and hangs in an unused room with a north light. The height of the cistern above mean sea level at Devonport Dockyard is 125·9 feet, as ascertained by levels from Ordnance datum mark, executed by Plymouth Borough Engineer. The reduction of observations to sea level is effected by tables specially supplied by the Meteorological Office.

The thermometers are exposed in a Stevenson screen of the usual pattern, open below. A complete duplicate set of thermometers is kept in readiness in case of accident. Observations are made with Negretti and Zambra's ozone tests, the papers being hung in the Stevenson screen.

The rain gauge is of Meteorological Office pattern, with circular rim 8 inches in diameter. Height of rim above ground 0·62 foot, above mean sea level 117·7 feet.

The Campbell-Stokes sunshine recorder is placed on the roof of the Laboratory, at the point where the eye observations of wind, cloud, and weather are made. The instrument fits into a frame mounted on an adjustable stage, so that it can be removed and replaced without further adjustment. The place of observation is in lat. 50° 21′ 49″ N., long. 4° 8′ 21″ W., as determined by measurements from the dial on the Breakwater, of which the position is accurately laid down on the chart.

The hours of observation are 9 a.m. and 9 p.m. local time, or 9 h. 16·5 m. Greenwich time. It was found impossible to take regular daily observations with greater frequency.

The ordinary routine work was begun on September 1st, and a table showing the means for the month is appended to these notes.

Mr. Merrifield has been kind enough to give me access to his father's meteorological records, and I hope to be able to discuss them fully in a future number of the Journal. In the meantime a few of the more obvious results may be of interest.

The position of the observing station was in lat. 50° 22′ 25″ N., long. 4° 7′ 16·5″ W. From the commencement of the observations the instruments were 90 feet above mean sea level up to July, 1873. They were then removed to a new position, cistern of barometer 69 feet above mean sea level; rain gauge 9 feet 2 inches above the ground. The hour of observation was 8 a.m. till 1887, when it was changed to 9 a.m.

Atmospheric Pressure.

The mean pressures, reduced to 32° F. and sea level (for the twenty-six years, 1865—1890), are as follows:

	Mean pressure, 8 a.m.		Monthly range.
January	29·956 inches	...	1·455 inch.
February	29·980 „	...	1·277 „
March	29·941 „	...	1·258 „
April	29·898 „	...	1·094 „
May	29·968 „	...	0·898 „
June	30·024 „	...	0·778 „
July	29·979 „	...	0·762 „
August	29·965 „	...	0·761 „
September	29·975 „	...	0·927 „
October	29·924 „	...	1·171 „
November	29·925 „	...	1·257 „
December	29·952 „	...	1·277 „
Means	29·957 „		1·076 „

The maximum pressure thus occurs in June, and the minimum in October and November. The month of greatest range is January; that of least, August. The highest recorded reading, 30·952 inches, occurs in January, 1882; and the lowest, 28·418 inches, in December, 1876. The highest monthly mean, 30·347 inches, is that for January, 1880; and the lowest, 29·422 inches that for December, 1876. It should be noted that for the reductions to sea level the tables supplied by the Meteorological Office have been employed.

For purposes of comparison I have taken the means for the fifteen years, 1870—1884, and beside these are placed means for the same years from Falmouth Observatory, the last named being extracted from the "Challenger" Report on Atmospheric Circulation,* and reduced to sea level by means of the table given in 'Instructions in the Use of Meteorological Instruments,' issued by the Meteorological Office.

	Plymouth.		Falmouth.		Differences.
January	29·991	...	30·003	...	−·012
February	29·944	...	29·946	...	−·002
March	29·970	...	29·979	...	−·009
April	29·880	...	29·896	...	−·016
May	30·013	...	30·025	...	−·012
June	29·986	...	30·002	...	−·016
July	29·968	...	29·983	...	−·017
August	29·962	...	29·977	...	−·015
September	29·961	...	29·962	...	−·001
October	29·899	...	29·915	...	−·016
November	29·897	...	29·908	...	−·011
December	29·943	...	29·959	...	−·016
Means	29·951		29·963		−·012

* Voyage of H.M.S. "Challenger," Physics and Chemistry, ii, pt. 5.

The correction for daily range in the above means for Plymouth is small, that derived from the Falmouth observations amounting to +0·003 inch during the month of June. I hope to determine its amount accurately by a full discussion of Dr. Merrifield's observations, supplemented by the readings of a Richard barograph now recording in the Laboratory.

Temperature.

The mean temperatures given below are calculated from the readings of maximum and minimum self-registering thermometers by the formula T. = Min. + K (Max. − Min.), where K has the following values :

Months	K.	Months	K.
January, December	0·520	April, September	0·476
February, November	0·500	May, August	0·470
March, October	0·485	June, July	0·465

(See title-page of Weekly Weather Report, 1884, Meteorological Office.)

Mean for Twenty-six Years, 1865—1890.

January .	41·9	June . . .	59·7	November .	46·4
February .	43·1	July . . .	62·6	December .	42·3
March .	43·9	August . .	62·0		
April . .	49·2	September . .	58·2	Mean .	51·2
May . .	53·8	October . .	51·5		

Taking the fifteen years 1870—1884 for Plymouth, we may compare with the same period for Exeter, Babbacombe, Prawle Point, Dartmoor (Princetown ?), and Bude as give in "Challenger" Report before quoted, reducing each to sea level by means of the correction 1° F. for 270 feet.

Stations.	Height in feet.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Plymouth	90	42·9	43·9	45·0	48·8	53·3	58·8	61·8	62·1	57·6	51·7	46·4	42·6	51·2
Exeter	164	41·1	43·2	44·9	48·8	53·9	59·5	63·4	63·1	58·1	51·4	44·4	41·2	51·1
Babbacombe . . .	293	42·9	44·1	45·0	48·3	52·9	58·5	62·0	62·3	58·3	52·4	46·8	42·8	51·4
Prawle Point . . .	350	43·4	44·3	45·0	48·1	52·3	57·3	61·1	61·6	58·5	52·8	47·5	43·9	51·3
Dartmoor	1372	42·1	43·1	44·6	48·9	52·3	58·0	61·0	61·1	57·5	51·4	45·9	42·4	50·7
Bude	16	42·1	43·4	44·6	48·3	52·6	57·8	60·6	61·3	57·7	52·4	45·9	42·6	50·8
Falmouth	211	45·2	45·5	45·8	48·8	52·9	58·1	61·1	61·7	58·4	53·4	48·4	45·2	52·0

From this table it appears that the curve of temperature at Plymouth is of a form intermediate between stations wholly exposed to the influence of the sea, and stations more inland. Thus on an average Plymouth is about 1° F. colder than Prawle Point during the winter months, and during the summer months about 1° F. warmer. On the other hand, Plymouth is 1·5° F. warmer than Exeter in winter, and in summer 1·5° colder. In spring and autumn the temperatures of these stations are almost identical, although it may be observed that in September the temperature of Plymouth shows a somewhat greater fall than occurs, *e. g.*, at Babbacombe, a a phenomenon which, although not fully confirmed by the mean of the longer period, suggests the influence of the high plateau of Dartmoor in some peculiar seasons.

Humidity.

The hygrometric conditions are shown by the following readings of dry and wet bulb thermometers, the values being means for twenty-six years as before.

	Dry.	Wet.	Dew-point.	Pressure of vapour. Inches.	Relative humidity. Per cent.
January	41·4	40·4	39·1	·238	92
February	41·8	40·8	39·5	·242	92
March	42·3	40·6	38·6	·234	87
April	48·2	45·8	43·2	·279	84
May	53·8	50·6	47·5	·329	79
June	59·9	56·3	53·2	·406	79
July	62·3	59·1	56·4	·456	82
August	61·3	58·7	56·5	·457	85
September	57·2	55·5	54·0	·418	89
October	50·4	49·1	47·7	·331	91
November	45·1	44·0	42·7	·274	91
December	41·3	40·5	39·5	·242	94
Means	50·4	48·5	46·5	·317	87

Winds.

The following table gives the twenty-six years' average of the number of days in each month on which the wind blew from a point in each quadrant.

Month.	N. by E. to E.	E. by S. to S.	S. by W. to W.	W. by N. to N.	Calm.
January	6	6	10	5	4
February	6	5	8	6	3
March	9	4	7	8	3
April	9	6	6	6	3
May	8	8	7	6	2
June	5	7	7	8	3
July	4	5	10	9	3
August	5	5	9	8	4
September	6	5	8	6	5
October	7	5	7	7	5
November	7	4	8	7	4
December	6	5	9	6	5
Sums . . .	78	65	96	82	44

Taking the fifteen years 1870—1884 as before, and summing the values N.E. and E., S.E. and S., S.W. and W., N.W. and N., given in the "Challenger" Reports, for Falmouth at 8 a.m., we get the following:

Month.	Plymouth.					Falmouth.				
	N. by E. to E.	E. by S. to S.	S. by W. to W.	W. by N. to N.	Calm.	N. by E. to E.	E. by S. to S.	S. by W. to W.	W. by N. to N.	Calm.
January . .	7	6	10	4	4	4	9	11	7	—
February . .	6	6	8	5	3	4	8	11	5	—
March . . .	9	4	7	8	3	6	6	9	10	—
April . . .	9	6	6	6	3	9	5	8	8	—
May	9	5	7	8	2	9	6	7	9	—
June . . .	4	6	8	9	3	3	7	10	10	—
July . . .	3	5	11	9	3	3	6	14	8	—
August . . .	6	5	10	6	4	5	5	12	9	—
September .	6	4	8	7	5	4	6	11	9	—
October . .	8	5	7	6	5	4	8	10	9	—
November . .	8	4	8	7	3	4	6	11	9	—
December . .	6	5	8	7	5	3	6	12	10	—
Sums . .	80	60	100	82	43	58	78	126	103	—

These sums for the year for Plymouth are in close agreement with those for the longer period, and we observe, as compared with Falmouth, a considerable average of calms, and excess of north-easterly winds, which again point to the influence of high land as hinted in the temperature curve.

Rainfall.

The rainfall of Plymouth is an element the discussion of which raises many problems of the greatest interest, on account of its

peculiar position with respect to the entrance to the English Channel and to the high plateau of Dartmoor. The whole question is well worthy of full investigation. In the meantime one may give Dr. Merrifield's observations as they stand.

Averages for Twenty-six Years ending December, 1890.

	Rainy days.		Amount in inches.
January	19·4	...	3·965
February . . .	16·4	...	2·960
March	14·0	...	2·615
April	13·5	...	2·252
May	12·1	...	2·140
June	12·0	...	1·892
July	14·5	...	2·839
August	14·2	...	2·680
September . . .	14·3	...	3·692
October	18·4	...	3·660
November . . .	17·3	...	3·557
December . . .	18·4	...	3·775
Totals . . .	184·5		36·027

The following notes are given by Dr. Merrifield :—" The average for five years is taken from the Quarterly Weather Report, Meteorological Office, January to March, 1870; rain gauge not used until January, 1869. In ten years from 1869 to 1878, Mr. Balkwill, Old Town Street (Plymouth), had 412·05 inches; Navigation School, 363·19 inches. Hence 13·45 per cent. should be added to Navigation School amounts. In five years from 1870 to 1874 Mr. Balkwill had 196·94 inches; Navigation School, 171·09, or add 15·11 per cent. to Navigation School; Drake's reservoir, 201·43 inches and 895 rainy days; Navigation School, 171·09 inches and 865 rainy days. Hence add 17·73 per cent. rain and 3·47 per cent. number of rainy days to Navigation School."

Sunshine.

Dr. Merrifield's records of the duration of sunshine begin with the year 1882. We have accordingly nine complete years, with the following results :

	Total sunshine. Hrs.	Min.		Percentage of possible.
January	41	33	...	16
February	76	48	...	27
March	130	27	...	36
April	171	53	...	42
May	198	25	...	40
June	202	59	...	42
July	187	17	...	38
August	197	52	...	45
September	146	56	...	39
October	98	25	...	30
November	57	57	...	22
December	49	56	...	20
Total	1560	28		33

Whence it appears that on the whole Plymouth enjoys one third of the possible bright sunshine, the proportion rising to nearly one half in August, and falling to one sixth in January.

The foregoing results are deduced from the averages computed by Dr. Merrifield, and comparisons have been made only with the material immediately to hand. They are, however, sufficient to show the great value of Dr. Merrifield's records, and of what may be expected from a full discussion.

Meteorological Observations at M.B.A. Laboratory, Plymouth, September, 1891, *9 a.m. and 9 p.m.*

{ Lat. 50° 21′ 49″ N. Long. 4° 8′ 21″ W. }

Height of cistern of barometer above mean sea level 125·93 feet.
" rain gauge " " 117·67 "
" " " ground 0·62 foot.

Day of month.	Mean barometer red. to 32° and sea level.	Temperature.					Elastic force.	Relative humidity. Sat.=100.	Wind.			Cloud amount, 0—10.		Sunshine, hours.	Ozone, 0—10.	Rain.	Remarks.
		Dry bulb.	Wet bulb.	Max.	Min.	Dew-point.			Direction. 9 a.m.	Direction. 9 p.m.	Mean force, 0—12	9 a.m.	9 p.m.				
1	29·627	57·7	55·3	62·4	56·0	53·1	·405	84	S.S.W.	S.S.W.	2	10	0	—	4	·000	Gale in forenoon.
2	29·872	56·2	55·0	60·2	54·7	54·0	·418	92	S.S.W.	Calm	1	10	0	1·70	1	·000	
3	29·979	57·7	55·2	61·6	53·8	52·9	·402	83	S.E.	S.W.	1	2	1	10·27	6	·000	Lightning at midnight.
4	30·102	56·7	54·8	62·8	54·7	53·1	·405	84	S.W.	S.W.	2	7	0	9·34	4	·000	
5	30·198	57·1	53·3	61·2	53·8	49·9	·360	77	S.W.	S.W.	3	7	0	4·61	5	·000	
6	30·015	57·3	56·2	61·5	55·6	55·2	·432	93	S.W. × W.	S.W. × S.	4	10	10	2·73	6	·275	
7	30·027	58·2	58·1	62·1	56·4	58·0	·482	100	S.S.W.	S.S.W.	1	10	10	0·71	7	·025	
8	30·114	60·6	58·1	64·0	57·1	55·9	·449	85	S.	N.E.	2	0	9	5·10	6	·010	
9	30·092	64·6	60·7	73·4	55·8	57·5	·474	79	E.S.E.	N.E. × N.	1	1	0	11·05	4	·000	
10	30·093	65·6	59·9	73·6	59·8	55·4	·439	70	E.N.E.	Calm	1	0	0	11·51	2	·000	
11	30·097	66·6	60·3	75·2	53·9	55·4	·440	68	E.N.E.	E. × N.	1	0	0	11·10	1	·000	
12	30·004	69·0	62·0	76·3	54·8	56·5	·459	65	E. × N.	N.E.	1	0	0	11·17	4	·000	Faint lunar halo p.m.
13	29·812	63·5	60·9	70·6	60·9	58·6	·494	85	E.S.E.	E.N.E.	1	7	4	1·04	6	·004	
14	29·950	57·4	55·2	62·6	53·1	53·2	·414	86	E.S.E.	W.	1	10	0	2·17	7	·040	Wind force 7 in afternoon.
15	30·269	56·0	53·4	61·3	47·8	51·0	·376	84	W.	Calm	1	8	9	3·37	1	·002	
16	30·351	57·1	55·6	60·5	48·8	54·3	·422	90	S.	W.S.W.	1	10	8	0·00	7	·000	Lunar halo p.m.
17	30·166	59·6	58·6	62·6	55·2	57·7	·478	94	W.	S.W.	4	7	10	2·97	5	·147	
18	30·034	60·3	60·3	62·3	59·0	60·3	·523	100	W.	Calm	1	10	10	0·00	6	·470	
19	29·995	59·4	59·4	61·8	58·4	59·4	·507	100	S.W.	S. × E.	2	10	10	0·00	6	·270	
20	29·823	55·0	52·4	59·8	52·5	50·0	·361	83	W. × N.	W.N.W.	2	9	9	3·12	6	·194	Wind force 7 at 2 a.m. Bar. min. 5 a.m.
21	29·834	51·6	50·1	58·2	48·9	48·5	·342	89	W.S.W.	N.	2	10	10	4·18	4	·039	Wind N.W., force 8, at 2.30 p.m.
22	29·935	54·5	51·4	61·4	50·9	48·5	·343	80	N.	N.E.	2	7	0	8·00	3	·000	
23	30·160	54·0	52·5	62·1	44·6	51·2	·378	90	E.N.E.	N.N.E.	0	0	0	9·12	7	·378	Lunar halo at midnight.
24	30·166	57·0	57·0	59·2	50·8	57·0	·466	100	S.	Calm	3	10	10	0·08	7	·100	
25	30·115	57·9	57·4	59·4	56·9	56·9	·465	97	S.	S.	1	10	0	0·02	6	·030	
26	29·931	57·4	55·5	62·2	55·6	53·7	·415	88	S.W.	W.	3	10	10	1·20	4	·000	Wind S.W., force 8, from 4 to 6 a.m.
27	30·140	54·9	52·0	61·9	52·0	49·3	·352	82	W.S.W.	W.S.W.	2	8	0	8·06	7	·000	
28	30·156	58·1	56·7	61·1	45·0	55·3	·437	90	S.S.W.	S.	2	8	0	8·50	6	·000	
29	29·950	56·6	56·0	59·2	55·4	55·6	·442	96	S.S.W.	S.W.	3	10	3	0·00	8	·102	Wind S., force 7 at 6 a.m.; wind force 7 at 4 p.m.
30	29·814	57·7	55·9	61·2	47·7	54·4	·424	89	S. × W.	S.S.W.	5	8	0	8·17	4	·447	Gale from midnight till 5 a.m. on 1st.
Means	30·027	58·5	56·3	63·4	53·7	54·4	·427	86·8			1·9	7	4	5·01	5	·084	

Rain on 14 days.
Gales on 7 days.
Fog on 9 days.

Wind.

N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
3 ...	6 ...	5 ...	3 ...	11 ...	17 ...	10 ...	0 ...	5 days.

Notes on the Herring, Long-Line, and Pilchard Fisheries of Plymouth (continued).

By William Roach,
Associate Member.

I.—*Herring.*

Date.	Tide.	Wind.	Weather.	No. of boats.	Catch per boat.	Price per 100.	Locality.	Remarks.
1890 Nov. 7	Flood	N.W.	Squally	—	300 and under	8/0	Cawsand Bay	A few nets were put down in Cawsand Bay on the 4th inst. and overhauled on the 5th inst., and it was found that a few herrings had arrived. A great many are getting their boats and nets in readiness for the approaching season.
14	—	—	—	4	100—200	4/0	Duke Rock	If the weather continues fine, with not much rain, there will soon be an increase in the fishing.
18	Spring	S.W.	Dull	1	300	4/6	Rum Bay to E. end of Breakwater	—
				9	Very few	—		
19	Ebb	S.W.	Mild	16	2000 dn.	4/5–4/9	Rum Bay to Duke Rock	Large fish.
20	„	W.S.W.	Threatening	25	2000	3/1–3/5	Ditto	—
21	Neap	S.W.	Fine	80	500	3/4–3/8	E. end of Breakwater to the Cobbler Buoy	—
25	Ebb in Sound, flood outside	N. by E.	Moderate	8	800	3/4–3/6	N.W. of Staddon Heights, East Channel	Twelve boats with no fish.
26	Ebb in Sound, flood at sea	E. by N.	Stormy	2	200	—	—	Sixty boats went to sea, but owing to the bright moon only two boats took fish.
28	Flood	S.E.	Wet	10	100	3/6–3/8	Taken W. of Staddon Heights	Herrings fallen off considerably.
Dec. 2	Ebb	E.	Gloomy	30	500	3/0–3/6	In East Channel and the Sound	—
3	Ebb at sea, slack water in Sound	N.	„	30	800	2/9–3/0	Different stations in Sound	—
4	Ebb outside, slack water in Sound	N. Fresh	„	40	600	2/5	Outside Breakwater	—
5	Ebb	—	—	20 Sound boats	700	—	Melampus Buoy and Breakwater Fort	Cawsand boats only taking a few hundred in their moored nets in Cawsand Bay, took them up and put

								them in Whitsand Bay, and hauled them next day, taking from 10,000 to 12,000.
6	"	E. by S.	Wet	—	12,000	2/8–2/10	—	Small boats took their nets and moored them in Whitsand Bay, taking from 13,000 to 14,000 per boat.
8	—	—	—	3	10,000	3/0	Whitsand Bay	—
9	Flood	E.	Gloomy	16 Drift,	10,000	1/8–2/0	S. of Mothecombe	—
				9 Looe,	30,000	1/3	Whitsand Bay	—
				20 Sound	8000	3/0–3/9	Between Melampus and Drake's Island	Fifty boats with only a few fish.
10	"	E.	Fresh	20	10,000	1/6	East Bay	—
				8	30,000	1/3	West Bay	This lot of herrings in the Sound was taken at 8 o'clock, during low water. Little boats almost sinking with fish.
				—	8000	2/0	Sound	
11	"	E.	"	20	20,000	1/3–1/9	5 to 6 miles S.W. of Bolt Head	Sound fishery fallen off considerably. Boats still working, but taking no fish.
12	"	E.	Gloomy	3 Drift	30,000	1/3	S. of Mothecombe, 5 to 6 miles	—
13	"	E.	Fine	15 "	40,000 down	10/0 per 1000	Ditto	—
15	—	—	—	6 "	10,000	1/6–2/3	S.W. of Bolt Head, from there up and down	—
16	Flood	N.	Wet	12 "	—	2/0–2/4	5 to 6 miles S.W. of Bolt Head	—
17	Ebb	E.	Gloomy	20 "	20,000	1/6–3/0	Various stations	—
18	—	E.	Threatening	30 "	30,000	1/1–1/4	Between Mothecombe and the Bolt Head, 4 to 5 miles off land	—
20	Ebb	E.	Gloomy	25 "	20,000	1/0	Off Stoke Point	—
22	Slack water outside	E.	"	10 "	15,000	1/3	Off Stoke Point, Breakwater Light, S. of Mewstone	—
23	Ebb	E.	Fine	40 "	10,000	0/8–1/0	Various localities	—
24	"	E.	Gloomy	8 "	5000	0/8	Off Stoke Point	—
25	"	E.	"	5	2000	1/0	Ditto	—
26	Flood	E.	"	10	10,000	£2 10*s.* to £3 per last	6 miles S.E. of Stoke Point	—
27	"	E.	Very cold	8	5000	3/0	4 to 5 miles S. of Stoke Point	70 per cent. shotten (spent).
29	—	—	—	6	3000	2/10	2 to 3 miles off Stoke Point	The herrings have made no appearance in Sound this year.
30	Ebb	E.	Very cold	50	20,000	2/0–3/0	2 to 3 miles S. of Salcombe	—
31	"	E., blowing half a gale	Threatening for snow	80	30,000	2/8–2/10	Ditto	Two boats lost half their fleet of nets on account of heavy takes.

Date.	Tide.	Wind.	Weather.	No. of boats.	Catch per boat.	Price per 100.	Locality.	Remarks.
1891 Jan. 1	Ebb	E.	Threatening	5	12,000	Full 3/0, shotten 1/1–2/0	Off Mothecombe	60 per cent. shotten.
2	,,	E.	Fine	30	20,000	2/6–3/6	Off Mothecombe, Breakwater Light, between the Mewstone and land	—
3	,,	E.	Gloomy	10	10,000	Full 3/1, shotten 2/0	Same as 2nd inst.	—
6	Slack water outside, 3 hours ebb in Sound	E.	Moderate	40	40,000	Full 3/0–3/6, shotten 1/6–2/0	Between Stoke Point and Bolt Head, 4 to 8 miles off land	—
7	1st hour flood	N.E.	Cold	30	25,000	1/8–2/3	Ditto	70 to 80 per cent. shotten.
8	2nd hour flood	S.	Threatening	20	15,000	Full 2/0, shotten 1/6	From Whitsand Bay to Bolt Head	One or two shoals travelling west.
10	Flood	N.E.	Fine	20	20,000	1/8–2/3	Between Stoke Point and Bolt Head, 1 to 2 miles off land	—
12	,,	N.	Gloomy	10	20,000dn.	1/6–2/4	Ditto	—
13	,,	N.	,,	30	15,000	1/4–2/2	Same as 12th inst.	—
14	,,	N.	Bright	10	20,000	1/5–1/11	$1\frac{1}{2}$ miles E. of Stoke Point	It is many years ago since such numbers of herrings have appeared in the East Bay.
15	Slack water	E.	,,	30	30,000	1/5–2/0	1 to 3 miles S. of Stoke Point, from there to Bolt Head	—
16	Ebb	E.	,,	15	10,000	1/8–2/0	1 to 3 miles S. of Stoke Point	—
17	,,	E.	,,	10	10,000	2/0–3/0	Ditto	—
20	,,	S.W.	Stormy	6	1000	2/0	8 to 9 miles outside the Eddystone	—
26	—	—	—	20	400	1/6	In East Bay	—

II.—*Long-Line.*

The "Remarks" show very clearly how much difficulty is experienced in procuring suitable bait, and how this branch of the fishing industry is paralysed for want of it. The conclusion might also be drawn that salted pilchard makes but an indifferent bait.

Date.	Tide.	Wind.	Weather.	Bait.	Locality.	No. of boats.	Conger.	Ling.	Rays and skates.	Cod.	Pollack.	Other fish.	Remarks.
1890 Oct. 21	Ebb	N.W.	Fine	Squid	$\frac{3}{4}$ mile W. of the Eddystone	1	cwt. 3	12	Dozen. 3	—	1 doz.	3 doz. bream	—
22	,,	E.	,,	,,	6 miles S.E. of the Mewstone	1	,,	6	3	2	,,	—	—
,,	—	—	—	Pilchard	6 miles outside the Eddystone	1	—	700–800 spur dog-fish			—	—	Nothing but spur dogs (*Acanthias*) taken.
29	Flood	W.	Wet	Squid	1 mile N.W. of the Eddystone	1	5	12	1 doz.	2	2 doz.	2 doz. bream	—
31	,,	W.	Squally	,,	3 to 4 miles S.W. of the Bolt Head	3	5	5 to 6	1 to 2	2 to 3	1 to 2 doz.	1 doz. bream	Weather extremely bad for long-line fishing.
Nov. 5	—	—	—	Squid	$\frac{3}{4}$ to $1\frac{1}{2}$ miles S.E. of the Eddystone	3	4	10 to 12	2 to 3	3 to 4	1 doz.	—	—
14	Flood	S.	Wet	—	—	—	—	—	—	—	—	—	—
17	,,	S., moderate	Dull	Squid	5 to 6 miles S.E. of Stoke Point	3	3	7 to 8	2 to 4	3 to 4	5 to 6	—	—
19	Ebb	S.W.	Mild	—	On East Reites	1	2	12	2	—	—	—	—
21	—	—	—	—	Outside the Eddystone	2	—	—	3 to 4	—	—	—	Caught 100 spur dog-fish. There are a great number on the coast just now.
28	Flood	N.E.	Very cold	—	—	3	3	6	1 to 2	6	—	—	These boats only shot half their gear owing to strong wind.
Dec. 1	—	—	—	Squid	7 to 8 miles S. of Bolt Head	2	14 to 15	—	—	—	—	—	—
						1	5	6	2 to 3	6	—	—	4 to 5 hand-liners, which use 4 lines, landed 4 cwt. each.
						1	4						
3	Ebb	N.	Gloomy	,,	7 to 8 miles off the Bolt Head	4	8	12	2 to 4	12	—	—	—
4	,,	N.	,,	,,	,,	2	4 to 6	2	2 to 4	12	—	—	—

Date.	Tide.	Wind.	Weather.	Bait.	Locality.	No. of boats.	Conger.	Ling.	Rays and skates.	Cod.	Pollack.	Other fish.	Remarks.
							cwt.	Dozen.					
Dec. 16	—	—	—	—	8 to 10 miles S.W. of Falmouth	1	9	9	4	12	—	—	—
					Outside the Eddystone	1	5	—	2	—	—	—	Lost half their gear.
					Off Bolt Head	1	2	—	—	—	—	—	—
29	Flood	E.	Gloomy	Squid	4 to 5 miles S. of Stoke Point	2	4 to 5	3 to 4 1/6 ach	—	—	—	—	Owing to the strong east wind and strong tides, these boats had to shoot their long lines near home. All the conger run from only 4 to 12 lbs. in weight.
1891 Jan. 5	Ebb	E.	Fine	Squid and pilchard	6 to 8 miles S. of the Bolt Head	6	$10\frac{1}{2}$ down	12	7 to 8	—	—	—	The boat which had the largest catch had 900 hooks baited with squid and 500 with pilchard. It is very difficult for long-liners to shoot now, owing to the drift-net fishery, which is carried on all the week excepting Saturday night.
12	Flood	N.	Gloomy	—	15 miles S.W. of Eddystone	1	$1\frac{1}{2}$	—	4	—	—	—	1000 dog-fish.
					Between Start Point and Bolt Head, 6 to 7 miles off land	5			Taken no fish				The men say the reason why they took no fish was owing to the extreme cold and the strong tides. One boat lost all its long line. This is owing to the drift-nets becoming entangled in the buoys attached to the long lines.
Feb. 4	—	—	—	Half squid half pilchard	8 to 10 miles S.W. of Bolt Head	2	5	6	5 to 6	3	—	—	—
					$1\frac{1}{2}$ miles E., W., and S. of the Eddystone	5	3	£2 worth of rays, skates, ling, and cod			—	—	—
					14 miles S.W. of Eddystone	1	$2\frac{1}{2}$	—	Rays £1	—	—	—	—

				Pilchard	Off Falmouth, 7 miles S. of Mewstone	1	No conger	—	5	—	—	—	—
9	—	—	—	—	—	7	3	12	3 to 5	—	—	—	—
10	—	—	—	Pilchard	½ mile N.W. of Eddystone	5	2	—	3 to 4	—	—	—	—
11	—	—	—	"	4 miles S.W. of Bolt Head	5	5	12 to 24	5 to 6	—	—	—	These boats have been successful in obtaining plenty of pilchard bait (which realised 18/0 per 1000).
14	Ebb	S., light	Bright	Squid	5 miles S.W. of Bolt Head	10	5	12	6	—	—	—	—
16	"	S. by W.	Fine	"	5 to 6 miles S.W. of Bolt Head	4	10	12	3 to 4	5 to 6	—	—	Each boat spent 10/0 for bait.
19	"	E., strong	Gloomy	Pilchard	"	15	3	—	3 to 4	6 to 7	6 to 7	—	Pilchard sold this day for bait by auction realised 35/0 per 1000, then there was not enough for all the boats, weather being so fine and fish making good prices.
26	Flood	E.	Bright	Squid	25 miles S.W. of Eddystone	1	1½	12	9	—	—	—	The bait used had been salted a week. All other long-liners been in harbour for want of bait.
Mar. 7	—	—	—	—	—	—	—	—	—	—	—	—	Long-liners received pilchard bait from Falmouth this evening at 6 o'clock at a cost of from 25/0 to 30/0 per 1000, caught in moored nets. These boats have been in harbour for a week waiting for bait, and now they have it the weather is setting in stormy. The bait was salted.
23	—	—	—	Pilchard and squid	12 to 15 miles S.W. of Start Point	6	1	5 to 6	7	—	—	—	Bait been in salt for a fortnight.
24	—	—	—	Salt pilchard and squid	10 miles S. of the Deadman	3	1 conger	24	8	—	—	—	Other boats never saw a conger, only having a few rays.
25	—	—	—	Fresh squid	E. side of the Eddystone	1	5	—	—	—	—	—	—
				"	—	1	2½	—	2	—	—	—	—
				Salt squid 14 days old	—	1	—	—	—	—	—	—	—

III.—*Pilchards.*

If, from the data supplied by Mr. Roach, we make an estimate of the fish landed in each of the four months, the totals come to be—In Oct. 322,750; in Nov. 923,500; in Dec. 4,128,500; in Jan. 2,795,000. These figures give a total for the season of 8,169,750 pilchards.

Date.	Tide.	Wind.	Weather.	No. of boats.	Catch per boat.	Price per 1000.	Locality.	Remarks.
1890 Oct. 8	—	S.W.	—	30	4000 to 5000	11/0	—	—
15	—	S.	Foggy	12	10,000	11/0	—	—
16	—	N.W., strong	—	—	No pilchards	—	—	Too much wind for net-fishing.
20	—	—	—	—	—	—	—	—
21	Ebb	N.W.	Fine	15	2000 to 3000	13/0–15/0	6 to 8 miles W. of the Eddystone	—
22	,,	E.	,,	20	1000 and under	19/0	6 to 8 miles S.W. of Rame Head	—
23	,,	E.	,,	—	500	/0 per 100	Ditto	—
24	,,	W.	,,	20	2000	16/0	6 to 12 miles W. of the Eddystone	—
31	Flood	W.	Squally	12	1000	15/0	10 to 15 miles W. of the Eddystone	—
Nov. 10	,,	S.W.	Bright	3	15,000	21/0	5 to 6 miles S.S.W. of the Rame Head	Very large fish.
14	,,	S.	Wet	50	4000	20/0	4 to 6 miles S. and S.W. of Penlee Point	Each boat had a few herrings; also several hundred of half-grown mackerel.
17	Strong	S.E., moderate	Dull	20	2000	14/0	3 to 4 miles S.S.W. of the Eddystone	—
19	Ebb	S.W.	Mild	10	10,000	13/0	1½ miles N.W. of Eddystone, from there up and down	—
20	Ebb	W.S.W.	Threatening	20	20,000	11/0–11/6	5 miles S.W. of Rame Head, from there inside the Eddystone	—

21	Neap	S.W.	Fine	20	10,000	11/0–12/0	2 miles inside the Eddystone	—
22	Flood	W.	Moderate	5	50,000	11/0–12/0	3 miles S.S.W. of Rame Head	Taken at 1 o'clock in the morning, after the moon went down.
25	Ebb in Sound, flood outside	N. by E.	,,	15	10,000	13/0	Between Rame Head and Eddystone	—
26	Ebb in Sound, flood at sea	E. by N.	Stormy	10	5000	12/6–13/0	Ditto	Fifty boats without fish.
28	Flood for a short time	N.E.	Very cold	20	5000 and under	13/0	Between Penlee and Eddystone	Large quantity of boats only a few hundred fish. They were sold to the pilchard curers, and sent by vessels to Cornwall.
29	Flood	E., showers of small sleet	,,	10	2000 to 3000	13/0	Ditto	Several boats came back again owing to the strong wind.
Dec. 1	—	—	—	5	5000 to 6000	12/0	Ditto	The west country buyers will not take these fish because they were caught on Sunday.
5	—	—	—	60	—	13/0–14/0	Ditto	Owing to there being no seine pilchards in the west, there is a good demand for the drift pilchards here at present. All large boats came back again.
9	Flood	E.	Gloomy	7	30,000	14/0–15/0	10 miles outside the Eddystone	—
10	,,	E.	,,	20	10,000	16/0	8 to 10 miles S. of Plymouth	Owing to the strong east wind fish going to deeper water; largest catches outside the Eddystone.
11	,,	E.	,,	20	20,000	12/0	5 to 6 miles S.E. of Eddystone	—
12	,,	E.	,,	30	10,000	11/6–12/0	7 to 8 miles S. of Mewstone, from there in and outside the Eddystone	—
13	,,	E.	Fine	20	10,000	11/0	7 to 8 miles S. of Mewstone	These boats have taken 60,000 to 70,000 small mackerel in their pilchard and herring nets.
16	,,	N.W.	Wet	40	20,000	10/0–12/0	N.W. of the Eddystone	—
17	Ebb	E.	Threatening	12	20,000	12/0	Various localities	4000 to 5000 small mackerel in their pilchard-nets.
18	,,	E.	Gloomy	40	30,000	—	7 to 8 miles S. of Mewstone, from there S. and W.	—
23	Slack water outside	E.	Fine	10	10,000	12/0	N.E. of Eddystone	—

Date.	Tide.	Wind.	Weather.	No. of boats.	Catch per boat.	Price per 1000.	Locality.	Remarks.
Dec. 24	Ebb	E.	Gloomy	6	2000 to 3000	12/0	2 to 3 miles inside the Eddystone	—
29	—	—	—	—	—	—	—	Owing to the prevailing east wind, the pilchards have fallen off considerably during the last few months.
1891 Jan. 2	Ebb	E.	Fine	20	25,000	10/0–12/0	4 to 8 miles S.E. of Eddystone	—
3	,,	E.	Gloomy	15	25,000	6/0–8/0	Ditto	—
6	Slack water outside, 3 hours ebb in Sound	E.	Moderate	20	70,000	6/0–10/0	6 to 10 miles S.E. of Eddystone	—
7	1st hour flood	N.E.	Cold	7	20,000	10/0	Ditto	A large quantity of small mackerel taken in the pilchard-nets (but none in herring-nets), 4000 to 5000 down; sold at 2/0 to 3/0 per 100.
8	2nd hour flood	S.	Threatening	8	20,000	10/0	15 to 20 miles S. of P. H. Harbour	Almost all boats in harbour.
10	Flood	N.E.	Fine	10	10,000	8/0–10/0	8 to 10 miles S.E. of Eddystone	Some of these boats, having 2000 to 6000 small mackerel, sold at 2/0 to 2/6 per 100.
13	—	N.	Gloomy	5	6000	12/0	Ditto	2000 to 4000 small mackerel, sold at 3/0 per 100. There were never so many small mackerel taken before in this locality.
14	Flood	N.	Bright	5	6000	11/0	8 to 10 miles S.S.E. of Eddystone	One boat, 10,000 small mackerel, sold at 3/0 to 5/0 per 100.
15	Slack water	E.	,,	8	5000	12/0	8 to 9 miles S.S.E. of Eddystone	Several thousands of small mackerel, sold at 2/0 per 100.
16	Ebb	E.	,,	5	4000	12/6	Ditto	—
26	—	—	—	—	—	—	—	Pilchard season is now finished, and the buyers have stopped curing. There are two or three boats trying still. They catch bait for long-liners. Not nearly so many pilchards taken this year as last.
28	—	—	—	—	—	—	—	Both pilchard and herring boats now commence fishing mackerel.

Note on a British Cephalopod—Illex eblanæ (Ball).

By

William E. Hoyle,
Keeper of the Manchester Museum.

A SHORT time ago I received from my friend Mr. J. T. Cunningham a Cephalopod which had been taken by a trawler in the neighbourhood of Plymouth, with the remark that it appeared to fit well with the description of *Ommastrephes eblanæ* (Ball) as given by Forbes and Hanley,* and that it undoubtedly belonged to the genus *Illex* of Steenstrup.

I have compared the specimen with all the examples of the genus *Illex* at my disposal, and satisfied myself that Mr. Cunningham's surmise was correct; and since this species has generally been referred to the category of forms inadequately described,† I have much pleasure in acceding to the suggestion that I should contribute a few notes upon it to this Journal.

That the Cephalopod belongs to the genus *Illex* was at once obvious from (1) the smooth siphuncular recess, (2) the absence of fixing pads and cushions at the base of the tentacular club, and (3) the absence of a membranous wing on the third pair of arms. Two species of this genus have been hitherto described, *Illex coindeti* (= *Ommastrephes sagittatus, auctorum plurimorum*) from the Mediterranean, and *Illex illecebrosus* from the American coast. Both these have the horny ring of the large tentacular suckers either smooth or with broad truncated teeth, and the small suckers at the end of the tentacular club arranged in eight rows.‡ In the example from Plymouth the horny ring of the large tentacular suckers is armed with acute teeth, separated by interspaces broader than the bases of the teeth themselves, and the terminal tentacular suckers are in four (rather irregular) rows.

On referring to the definition of *Ommastrephes eblanæ* as given

* Brit. Moll., iv, p. 235, 1853.

† Steenstrup, Ommatostrephagtige Blæksprutter, p. 97 (27); Hoyle, "Challenger" Cephalopoda, p. 33.

‡ Steenstrup, loc. cit., p. 91 (21).

by Forbes and Hanley, we find it distinguished from *O. sagittatus* (*Illex coindeti*) by two characters : (1) body elongated in the latter, proportionately short in the former ; (2) terminal tentacular suckers in many (about eight) rows in the latter, in four rows in the former ; (3) the fin of *O. sagittatus* is rhomboidal, of *O. eblanæ* more elliptical. The character first mentioned is not specific but sexual, as may be seen from Verany's beautiful figures of the Mediterranean form ; * whilst as regards the two latter, the Plymouth specimen agrees with the description of *O. eblanæ*.

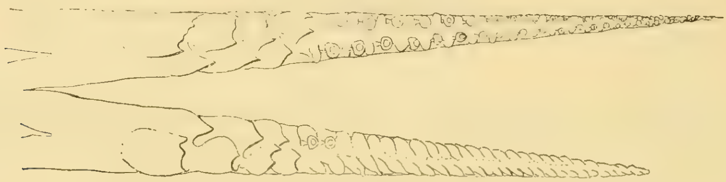


Fig. 1.—Ventral arms of *Illex eblanæ*, to show the hectocotylisation.

Among the specimens with which I have been able to compare it are two Irish examples, labelled *Ommastrephes eblanæ*, and presumably named by comparison with Ball's type, which I understand still exists in the museum of Trinity College, Dublin.†

It resembles these in all essential characters, and hence there can be no doubt that it belongs to the species which we must now call *Illex eblanæ* (Ball), whose synonymy and definition will be as follows :—

Illex eblanæ (*Ball*).

1841. Loligo eblanæ, *Ball.* Proc. Roy. Irish Acad., vol. i, p. 363, figs. 1—7.
1849. — — *Gray.* Brit. Mus. Cat., p. 65.
1853. Ammastrephes eblanæ, *Forbes and Hanley.* Brit. Moll., vol. iv, p. 235, pl. sss, fig. 2.
1856. Loligo eblanæ, *Thompson.* Nat. Hist. Ireland, vol. iv, p. 270.
1880. Ammastrephes eblanæ, *Steenstrup.* Ommatostrephagtige Blæksprutter, Oversigt k. Dansk. Vid. Selsk. Forhandl., p. 97 (27).

Fin very broadly rounded, sub-elliptical (see figs. 2, 3) ; *tentacular*

* Moll. médit., Céph., pls. xxxi, xxxii, 1851.

† Since the above was in type my friend Dr. Scharff, to whom I am indebted for much help regarding the Irish specimens, informs me that he has compared my description of the Plymouth specimen sent to him for the purpose with Ball's type. "This has," he says, "been very much knocked about, and could not be taken out of the bottle. It is a much smaller specimen, . . . and . . . the fin was more elongated in the type," but that otherwise the description fitted.

club with the central suckers about four times as great in diameter as the laterals, and provided with very acute teeth, separated by interspaces somewhat larger than the breadth of the tooth at its base; terminal suckers in four rows.

Habitat.—Britain: Dublin Bay (Ball), Antrim (Museum of Science and Art, Dublin, *fide* Scharff); North Sea (Captain Gray); Plymouth (Marine Biological Laboratory); Mediterranean: Naples (Zoological Station).

Among the material examined were four males, which exhibited the interesting form of hectocotylisation I now propose to describe

FIG. 2.—Fin of *Illex eblanæ.*

(see fig. 1). The alteration affects both arms symmetrically in their basal portions, but the right arm only is modified to the tip. About 2 cm. from the base of each arm, instead of a sucker, is a flattened bract-like appendage, growing out from a broad base. Its distal margin is slightly notched, and at the inner extremity bears a sharp tooth; at the outer margin it curves into the general surface of the arm. On the outer side of the oval surface of the arm this appendage is succeeded by three similar ones, gradually decreasing in size. On the inner margin of the arm, alternating with them, are three conical teeth, also directed towards the tip of the arm. The points of all these teeth are tough, and feel almost cartilaginous. Beyond this the left arm presents the normal arrangement of suckers, but the right arm has only two suckers placed near the inner margin; on the outer margin is a series of conical tubercles, ex-

tending the whole way to the tip and gradually diminishing in size. The inner margin is occupied by a series of slight swellings, some of the proximal ones of which look as though suckers had fallen from them.

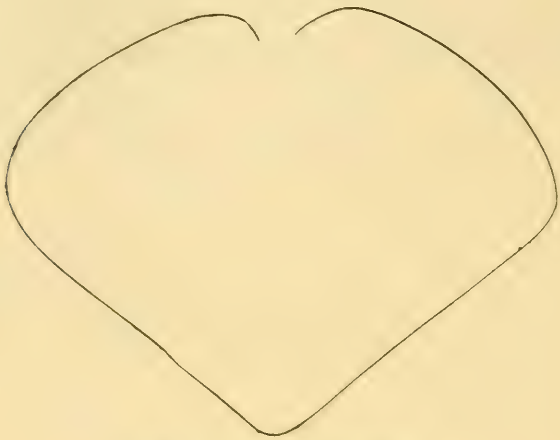


FIG. 3.—Fin of *Illex coindeti.*

The series of four males which I have examined exhibit some interesting facts regarding the development of these structures. The above description is taken from a specimen about 27 cm. in length (excluding the tentacles) ; in a somewhat smaller one, 20 cm. in length, the bract-like appendages are smaller and (except the basal one) shelter suckers beneath them : the suckers extend on the outer margin of the arm nearly halfway along it, and on the inner margin along three quarters of its length before they give place to the conical or rounded prominences.

In two still smaller specimens (about 10 cm. long) both series of suckers are present up to the tips of the arms, and the bract-like appendages are just beginning to appear at the bases of from three to five proximal suckers. It would appear, therefore, that on these hectocotylised arms suckers are normally developed, and then gradually disappear as the animal approaches maturity.

NOTES AND MEMORANDA.

On the Occurrence of the Nudibranch Hancockia at Plymouth.—I am glad to be able to record a second English specimen of this interesting form. It was dredged, apparently on *Delesseria,* in Plymouth Sound, about halfway between Drake's Island and the west end of the Breakwater, on August 20th, 1891.

Mr. A. R. Hunt, the original discoverer of *Hancockia,* dredged a single example in Tor Bay in August, 1877. This was described by Mr. Gosse under the name *Hancockia eudactylota* (Annals and Mag. of Nat. Hist., Ser. 4, vol. xx, 1877).

In January, 1885, four specimens, representing two closely allied forms, were taken near Naples, and described by Prof. Trinchese (Ricerche Anatomiche sul Genere *Goria,* 1886). He defined the genus *Goria,* apparently in ignorance of Gosse's paper, including his forms under two species, *G. rubra* and *G. viridis.*

The Plymouth specimen is about a quarter of an inch in length when extended. This is only half the length of Mr. Hunt's specimen and of Prof. Trinchese's *Goria rubra.*

It is of a dark claret colour, very similar to that of the *Delesseria* on which it lived.

The epidermis of the upper surface, seen by reflected light, is of a delicate bluish-green hue, as in *Hancockia eudactylota* (Gosse, loc. cit., p. 317).

There are four pairs of pleuropodial processes, with a rudiment of a fifth on the left side.

In its other characters, this specimen is apparently intermediate between *H. eudactylota* and *Goria rubra.*

In the number of processes of the oral veil (four on each side), in the form of the rhinophoral sheaths, and in the absence of the white spots which Trinchese has described, it agrees with *Hancockia* and differs from *Goria rubra.*

In the absence of rudimentary oral processes described by Gosse between the well-developed ones, in the presence of a more or less circular pigment patch at the base of the pleuropodial expansions, and especially in the form of the latter, it agrees with *Goria rubra* and differs from *Hancockia.*

More specimens, however, are required to settle the relations of these interesting forms.—F. W. Gamble.

Saphenia mirabilis, Haeckel.—In the same haul of the large tow-net in which the *Phyllosoma* elsewhere described were taken on the night of July 16th I captured a large number, some hundreds, of small Medusæ of a single species. These proved on examination to be the *Goodsiria mirabilis* of Strethill Wright, described and figured by him in a paper in the Edinburgh Philosophical Journal, vol. lxvii, 1859. The species has been placed by Haeckel (System der Medusen, Jena, 1879) in Eschscholtz's genus *Saphenia,* of which two other species only have been described. No other observer than Strethill Wright has recorded or described *Saphena mirabilis,* and he took only three specimens near Queensferry in the Firth of Forth. Strethill Wright's specimens were about an inch in diameter; those taken near the Eddystone were not so large, the largest being only about 12 mm. The species, however, is certainly the same; it is distinguished by the depressed form of the umbrella, the presence of only two extensile tentacles, and a very long and very extensile peduncle several times as long as the breadth of the umbrella. The genus *Saphenia* is placed by Haeckel in the family *Eucopidæ* of the order *Leptomedusæ.* All the *Leptomedusæ* whose development is known are developed asexually from a fixed hydriform stock. The development of *Saphenia* is at present entirely unknown, but it seems probable that the numerous specimens taken near the Eddystone were derived from some fixed hydroid which flourishes at the bottom of the sea in that neighbourhood.—J. T. Cunningham.

Pleurophyllidia Lovéni, Bergh.—Another interesting capture made last summer was that of the rare Opisthobranch *Pleurophyllidia Lovéni,* Bergh. A single specimen was taken in the shrimp trawl, about two miles to the north of the Eddystone on the night of July 9th. It was accompanied by many Nudibranchs and a Pleurobranchus; these Molluscs, as well as the Pleurophyllidia, were identified by Mr. W. Garstang, and the list of them is as follows:

Pleurobranchus membranaceus, 1 specimen; *Acanthodoris pilosa,* 10 specimens, all white; *Philine aperta,* 3; *Scaphander lignarius,* 1; *Eolis* sp., several.

The other contents of the trawl were a few small flat-fishes, a number of *Pecten opercularis,* and a large quanty of Cellaria. Only two specimens of *Pl. Lovéni* are reocrded as taken in the British area by Forbes and Hanley, and by Gwyn Jeffreys. But Mr. Holt has recently recorded the capture of two specimens in St.

Andrew's Bay; he obtained them from fishermen's haddock-lines (Ann. and Mag. Nat. Hist., August, 1891).—J. T. C.

Breeding of Fish in the Aquarium.—At the end of March the plaice in the large flat-fish tank were spawning, and the eggs floated at the surface of the water. But when examined, none of the eggs were found to be fertilized. A hatching box of Captain Dannevig's pattern had recently been fitted up in the aquarium for hatching floating eggs. I took out some of the ripe plaice and fertilized a number of eggs from them artificially. Some of the females yielded healthy eggs, and large numbers of these were successfully hatched in the hatching box. But some of the females yielded only ripe eggs which were already dead; the difference between these and unripe eggs being perfectly obvious. These same plaice spawned in the tank in 1890, and the eggs were naturally fertilized and found in a developing condition at the surface in the tank. It seems as though a prolonged residence in the water of the aquarium produced some abnormal disturbance of the reproductive functions in these plaice. In the same tank were two ripe female flounders, but no males of the same species. I squeezed a large number of eggs from these, and made the experiment of mixing them with milt from a male plaice. Fertilization occurred in a certain number of the ova, about half, and a few of these lived till they were hatched, and the larvæ lived several days. They died, however, like all my larvæ, soon after the absorption of the yolk-sac. In April and May many of the soles in the flat-fish tank were much swollen in the abdominal region, and it seemed as if the ovaries ware enlarged and the eggs on the point of being shed. But no soles' eggs ever appeared in the tank, although arrangements were made that no floating eggs shed in the tank could escape. After a time many of the soles gradually lost the swollen appearance. I took out a specimen 25 cm. long on June 10th, and found it was a male, and on teasing up a portion of the testis saw a considerable number of ripe active spermatozoa mixed with unripe spermatic cells. Afterwards I squeezed a swollen female, but no ripe eggs were expelled, but, instead, some curious translucent masses whose nature I did not understand. On June 27th I took out a large female sole which was still swollen, and on squeezing obtained some more of these masses of soft substance. When teased up under the microscope the substance proved to consist of degenerate ripe ova, looking as though they had been half digested. The vitelline membranes were present, but shrivelled and containing only granules of dead matter. I then opened the ovary, and found more of these masses in its cavity; the ovary itself was

crowded with eggs not quite ripe. It appears, therefore, that in these soles the eggs, when nearly ripe, escaped in successive lots into the cavity of the ovary, and there died and degenerated. It is evident that soles will not spawn in our tanks. These specimens had been living in the same tank since the summer of 1889, and they showed no signs of spawning in 1890. Whether the cause of this inability to breed is merely the confinement, or the shallowness of the water in a tank compared to the depth of the sea, or the quality of the water, there is at present no evidence to show.—J. T. C.

The Amount of Fat in Different Fishes.—An inquiry has recently been made concerning the above, and in consequence of this I have made a number of determinations of the amount of fat in the flesh or muscle of various species. The fat was extracted with ether in a fat extraction apparatus ; the ethereal solution thus obtained was separated from any water which happened to be present, and dried over calcium chloride. The ether was then distilled off, and after being heated to 100° C. the residue was weighed. The following table gives the results obtained :

Common name of fish.	Scientific name.	Weight of fish taken.	Weight of extract.	Percentage of fat.
		Grms.	Grms.	
Piper	Trigla lyra	150	0·250	0·166
Red gurnard	Trigla cuculus	135	0·192	0·142
Mackerel	Scomber scombrus	200	3·05	1·52
,,	,,	200	2·52	1·26
Thickback	Solea variegata	78	0·014	0·018
Turbot	Rhombus maximus	166	0·028	0·017
John Dory	Zeus faber	166	0·144	0·086
Hake	Merluccius vulgaris	190	0·057	0·030
Haddock	Gadus æglefinus	190	0·009	0·005
Pollack	Gadus pollachius	190	0·011	0·006
Cod	Gadus morrhua	190	0·009	0·005
Ling	Molva vulgaris	150	0·032	0·022

F. Hughes.

ERRATUM.

In Mr. Cunningham's paper in the previous number of the Journal, p. 17, line 25, *for* 6 lbs. *read* 2 lbs.

LIST

OF

Governors, Founders, and Members.

1st MAY, 1892.

I.—Governors.

The British Association for the Advancement of Science, 22, *Albemarle Street, W.* £500
The University of Cambridge £500
The Worshipful Company of Clothworkers, 41, *Mincing Lane, E.C.* £500
The Worshipful Company of Fishmongers, *London Bridge* £2000
The University of Oxford £500
Bayly, Robert, *Torr Grove, Plymouth* £1000
Bayly, John, *Seven Trees, Plymouth* £600

II.—Founders.

* Member of Council. † Vice-President. ‡ President.

1884 The Corporation of the City of London £210
1888 The Worshipful Company of Drapers, *Drapers' Hall, E.C.* £210
1884 The Worshipful Company of Mercers, *Mercers' Hall, Cheapside* ... £315
1884 The Worshipful Company of Goldsmiths, *Goldsmiths' Hall, E.C.*... £100
1889 The Worshipful Company of Grocers, *Poultry, E.C.* £100
1884 The Royal Microscopical Society, *King's College, W.C.* £100
1884 The Royal Society, *Burlington House, Piccadilly, W.* £250
1884 The Zoological Society, 3, *Hanover Square, W.* £100
1884 Bulteel, Thos., *Radford, Plymouth* £100
1884 Burdett-Coutts, W. L. A. Bartlett, 1, *Stratton Street, Piccadilly, W.* £100
1888 Bury, Henry, B.A., *Trinity College, Cambridge* £100
1884 Crisp, Frank, LL.B., B.A., V.P. and Treas. Linn. Soc., 17, *Throgmorton Avenue* £100
1884 Daubeny, Captain, *Lutton, South Brent, S. Devon* £100
1885 Derby, The Rt. Hon. the Earl of, K.G., 33, *St. James's Square, S.W.* £100
1884 Eddy, J. Ray, *The Grange, Carleton, Shipton, Yorkshire* £100

1884 Gassiott, John P., *The Culvers, Carshalton, Surrey* £100
‡*1884 Lankester, Prof. E. Ray, F.R.S., 2, *Bradmore Road, Oxford*......... £100
1884 Lister, S. Cunliffe, *Swinton Park, Masham, Yorkshire*.................. £100
†1884 Lubbock, The Rt. Hon. Sir John, Bart., M.P., F.R.S., *High Elms, Bromley, Kent* £100
*1884 Poulton, Edward B., M.A., F.R.S., *Wykeham House, Oxford*......... £100
†1889 Revelstoke, Lord, *Membland, Yealmpton, S. Devon* £100
1890 Riches, T. H., B.A., *Inglenook, Yelverton, S. Devon*...................... £100
1884 Romanes, G. J., LL.D., F.R.S., *St. Aldate's, Oxford* £100
†1884 Thomasson, John P., M.P., *Woodside, near Bolton* £350
†1889 Thompson, Sir Henry, 35, *Wimpole Street, W.* £100
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III.—Members.

ann. signifies that the Member is liable to an Annual Subscription of One Guinea.
C. signifies that he has paid a Composition Fee of Fifteen Guineas in lieu of Annual Subscription.

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1884 Adkins, J. E., *Yealmpton, Plymouth* .... *ann.*
1886 Adlard, J. E., 22½, *Bartholomew Close, London, E.C.* .... *ann.*
1884 Alger, W. H., *Manor House, Stoke, Devonport* .... *C.*
†1884 Allman, Prof. G. J., F.R.S., *Ardmore, Parkstone, Dorset* £20
†1884 Argyll, The Duke of, K.G., *Argyll Lodge, Kensington, W.* .... *C.*
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1884 Ashworth, J. W., M.R.C.S., 40, *Benyon Road, Kingsland, N.*............. *ann.*
1892 Assheton, R., *Moss Grove Villa, Moss Lane, E. Manchester* .... *ann.*

1890 Badger, A. B., B.A., *Merton Lodge, Oxford Road, Moseley, Birmingham* *ann.*
1884 Bailey, Charles, F.L.S., *Ashfield, College Road, Whalley Range, Manchester* .... *ann.*
1888 Balfour, Henry, 11, *Norham Gardens, Oxford* .... *ann.*
1884 Balfour, Prof. Bayley, F.R.S., *Royal Botanic Gardens, Edinburgh*... *C.*
1888 Balkwill, A. P., 2, *Lipson Terrace, Plymouth* .... *ann.*
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1890 Barnes, J. J., M.R.C.S., *Blackburn Road, Bolton* .... *ann.*
1884 Bateson, Wm., *Morphological Laboratory, New Museums, Cambridge* *ann.*
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1884 Bayly, Miss, *Seven Trees, Plymouth* £50
1884 Bayly, Miss Anna, *Seven Trees, Plymouth* £50
1888 Bean, Chas. E., 5, *Buckland Terrace, Plymouth* .... *ann.*
1884 Beard, John, B.Sc., *Fishery Board for Scotland, Edinburgh* .... *ann.*
1884 Beaumont, W. J., 9, *New Square, Cambridge* .... *ann.*
1885 Beck, Conrad, 68, *Cornhill, E.C.* .... *C.*
*1889 Beckwith, E. L., *Millfield, Chislehurst* .... *ann.*
1887 Beddard, F. E., *Zoological Society's Gardens, Regent's Park, N.W.* ... *ann.*
1884 Beddington, Alfred H., 8, *Cornwall Terrace, Regent's Park, N.W.*... *C.*

*1884 Bell, Prof. F. Jeffrey, 5, *Radnor Place, Gloucester Square, W.*........ ann.
1887 Berrington, A. D., *Board of Trade, Whitehall*........ ann.
1890 Bidder, George, B.A., *Parker's Hotel, Napoli, Italy*........ C.
1885 Bignell, Geo. Carter, M.E.S., 7, *Clarence Place, Stonehouse*........ ann.
†1885 Birkbeck, Sir Edward, Bart., M.P., 10, *Charles Street, Berkeley Square, W.*........ ann.
1885 Blandford, W. F. H., 48, *Wimpole Street, W.*........ ann.
1890 Bodley, Miss E. W., *Parkstone, Dorset*........ ann.
1889 Bolitho, T. B., M.P., *Trewidden, Penzance*........ ann.
1884 Bompas, G. C., 4, *Gt. Winchester Street, E.C.*........ ann.
1884 Bossey, Francis, M.D., *Mayfield, Redhill, Surrey*........ ann.
1884 Bostock, E., *Stone, Staffordshire*........ ann.
1890 Bourne, Prof. A. G., *The Presidency College, Madras*........ ann.
1884 Bourne, Gilbert C., 10, *Erith Road, Belvedere, Kent*........ ann.
1884 Bowman, Sir W., Bart., LL.D., F.R.S., 5, *Clifford Street, Bond Street, W.*........ £20
1884 Bradford, J. Rose, B.Sc., 30, *Blomfield Street, Upper Westbourne Terrace, W.*........ ann.
1886 Brent, Francis, F.S.A., 6, *Tothill Avenue, Plymouth*........ ann.
1890 Brindley, H. H., B.A., *St. John's College, Cambridge*........ ann.
1886 Brooksbank, Mrs. M., *Leigh Place, Godstone, Surrey*........ C.
1884 Brown, Arthur W. W., 6, *Sussex Square, W.*........ C.
1884 Buckton, G. B., *Weycombe, Haslemere*........ ann.
1886 Bullar, Miss Anna K., *Bassett Wood, Southampton*........ ann.
1887 Burd, J. S., *Cresswell, Higher Compton, Plymouth*........ ann.
1889 Burnard, Robert, 3, *Hillsborough, Plymouth*........ ann.

1884 Caine, H. T., 5, *Upper Wimpole Street, W.*........ C.
1884 Caine, W. S., M.P., 132 and 133, *Palace Chambers, Bridge Street, S.W.*........ £21
1890 Calderwood, Prof. H., LL.D., F.R.S.E., 7, *Napier Road, Edinburgh* ann.
1887 Caldwell, W. H., 12, *Harvey Road, Cambridge*........ C.
1888 Carkeet, John, C.E., *Ladywell, Plymouth*........ ann.
1885 Carpenter, Dr. P. Herbert, F.R.S., *Eton College, Windsor*........ C.
1887 Carter, James, F.G.S., 30, *Petty Cury, Cambridge*........ ann.
†1884 Chamberlain, Rt. Hon. J., M.P., 40, *Princes Gardens, S.W.*........ ann.
1884 Chapman, Edward, *Magdalen College, Oxford*........ ann.
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1884 Clay, Dr. R. H., *Windsor Villas, Plymouth*........ ann.
1885 Clerk, Major-Gen. H., F.R.S., 40, *St. Ermin's Mansions, Caxton Street, S.W.*........ £21
1886 Coates and Co., *Southside Street, Plymouth*........ C.
1889 Cole, A. C., 64, *Portland Place, W.*........ ann.
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1891 Cornish, T. H., 4, *Clarence Place, Penzance*........ ann.
1890 Coxeter, S., 4, *Grafton Street, W.C.*........ ann.
1884 Crofton, Edward, 45, *West Cromwell Road, Earl's Court, S.W.*........ ann.
1889 Crossman, Major-General Sir William, K.C.M.G., M.P., *Cheswick, Northumberland*........ ann.

1885 Cunningham, Geo., M.A., D.D.S., 2, *King's Parade, Cambridge* ...... *ann.*
1889 Cunningham, J. T., M.A., F.R.S.E., 1, *Sussex Place, Plymouth* ...... *ann.*

1889 Darbishire, R. D., *Victoria Park, Manchester* .... *ann.*
1885 Darwin, Francis, F.R.S., *Trinity College, Cambridge* .... *C.*
1885 Darwin, W. E., *Ridgemount, Bassett, Southampton* £20
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1888 Daw, R. Harvey, *Marsh Mills, Plympton* .... *ann.*
1889 Deacon, J. Barrington, 11, *Osborne Place, Plymouth* .... *ann.*
1885 Deby, Julien, C.E., 31, *Belsize Avenue, N.W.* .... *ann.*
1885 Dendy, Arthur, B.Sc., *University of Victoria, Melbourne, Australia*... *ann.*
1884 Dewick, Rev. E. S., M.A., F.G.S., 26, *Oxford Square, Hyde Park, W.* *C.*
1885 Dixey, F. A., M.A.Oxon., *Wadham College, Oxford* .... £26 5*s.*
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1884 Dunning, J. W., 4, *Talbot Square, W.* ....£26 5*s.*
1885 Durham, A. E., *Christ's College, Cambridge* .... *C.*
*1884 Dyer, W. T. Thiselton, M.A., C.M.G., F.R.S., *Director of the Royal Gardens, Kew* .... *C.*

1887 Ebrington, Viscount, M.P., *Castle Hill, North Devon* .... *ann.*
1884 Edmonds, R. G., *Mount Drake, Plymouth* .... *ann.*
1889 Elliot, George Henry, Lieut.-Col. and Paymaster R.M.L.I., 80, *Durnford Street, Stonehouse, Plymouth* .... *ann.*
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*1884 Evans, John, D.C.L., Treas. R. Soc., *Nash Mills, Hemel Hempstead* £20
*1885 Ewart, Prof. J. Cossar, *University, Edinburgh* £25

1884 Fayrer, Sir Joseph, M.D., K.C.S.I., F.R.S., 53, *Wimpole Street, W.* *ann.*
1884 Fison, Frederick W., *Greenholme, Burley in Wharfedale, Leeds* ...... *C.*
*†1884 Flower, Prof., C.B., F.R.S., Director of the British Museum of Natural History, *Cromwell Road, S.W.* .... *C.*
*1885 Fowler, G. Herbert, B.A., Ph.D., 12, *South Square, Gray's Inn, W.C.* *ann.*
1884 Fox, George H., *Dolvean, Falmouth* .... *ann.*
1889 Fraser, James, *Langthorne House, Copthall Avenue, E.C.* .... *ann.*
1889 Freake, Sir Thomas S., *Warfleet, Dartmouth* .... *ann.*
1886 Freeman, F. F., *Abbotsfield, Tavistock, S. Devon* .... *C.*
1889 Frost, Mrs. E., 30, *Woburn Place, Russell Square* .... *ann.*
1884 Fry, George, F.L.S., *Focklesbrook, Chobham, Surrey* £21
1884 Fryer, Charles E., *Board of Trade, S.W.* .... *ann.*

1885 Gadow, Dr. Hans, *King's College, Cambridge* .... *ann.*
1884 Galton, J. C., M.A., F.L.S., *New University Club, St. James's Street, W.* .... *ann.*
1887 Gamgee, Dr. A., F.R.S., 17, *Great Cumberland Place, W.* .... *ann.*
1890 Garstang, W., M.D., M.R.C.P.Lond., *Spring Well House, Blackburn* *ann.*
1891 Garstang, W., M.A., *The Laboratory, Citadel Hill, Plymouth* .... *ann.*
1885 Gaskell, W. H., F.R.S., *Trinity College, Cambridge* .... *C.*
1885 Gaskell, E. H., *North Hill, Highgate, N.* .... *C.*

1884 Gibson, Ernest, F.Z.S., *Buenos Ayres* .... ann.
1885 Glennie, W. R., *Berkeley Lodge, Wimbledon*.................................. ann.
1884 Godwin-Austen, Lieut.-Col. H. H., F.R.S., *Nore, near Bramley, Guildford* .... ann.
1884 Gonne, William, 32, *Sussex Gardens, W.* .... £26 5s.
1885 Gordon, Rev. J. M., *St. John's Vicarage, Redhill, Surrey* .... ann.
1885 Gotch, F., *Holywell Cottage, Oxford* .... ann.
1888 Goulding, F. H., *George Street, Plymouth*.................................. C.
1885 Green, J. R., *Trinity College, Cambridge* .... ann.
1886 Gresswell, D. Astley, 5, *Oakley Square, Camden Town, N.W.* .... ann.
1884 Grove, E., *Norlington, Preston, Brighton* .... ann.
1884 Groves, J. W., 61, *St. Ermin's Mansions, Caxton Street, S.W.*......... ann.
*1884 Günther, Albert, F.R.S., *Natural History Museum, Cromwell Road, S.W.*.................................. ann.

*1884 Haddon, Prof. Alfred C., M.A., *Royal College of Science, Dublin*...... ann.
1884 Halliburton, Prof. W. D., M.D., B.Sc., *King's College, Strand, W.C.*.................................. ann.
1890 Hamilton, J. Lawrence, M.R.C.S., 30, *Sussex Square, Brighton* ...... ann.
1884 Hannah, Robert, 82, *Addison Road, Kensington, W.* .... C.
1885 Harker, Allen, F.L.S., *Royal Agricultural College, Cirencester*......... ann.
1885 Harmer, S. F., *King's College, Cambridge* .... C.
1889 Harvey, T. H., *Cattedown, Plymouth*.................................. ann.
1888 Haselwood, J. E., 3, *Lennox Place, Brighton* .... C.
1884 Haslam, Miss E. Rosa, *Ravenswood, Bolton*.................................. £20
1884 Hayne, C. Seale, M.P., 6, *Upper Belgrave Street, S.W.*.................. ann.
1884 Head, J. Merrick, F.R.G.S., J.P., *Ardverness, Reigate* .... ann.
1884 Healey, George, *Brantfield, Bowness, Windermere* .... ann.
1884 Heape, Walter, *North Wood, Prestwich, Manchester* .... C.
1887 Heath, Miss A., 24, *George Street, Plymouth* .... ann.
1884 Heathcote, Fredk. G., *Trinity College, Cambridge* .... C.
1884 Herdman, Prof. W. A., *University College, Liverpool* .... ann.
1884 Herschel, J., Col. R.E., F.R.S., *Observatory House, Slough, Berks*... C.
1884 Herschel, Sir W. J., Bart., *Lawn Upton, Littlemore* .... ann.
1884 Heywood, James, F.R.S., 26, *Palace Gardens, W.* .... C.
1889 Heywood, Mrs. E. S., *Light Oaks, Manchester*.................................. C.
*1884 Hickson, Sydney J., M.A., D.Sc., *Downing College, Cambrige* .... ann.
1885 Hill, Alex., M.A., M.D., *Downing College, Cambridge*...................... ann.
1888 Hodge, H. Cotty, *Redland House, Vinstone, Plymouth* .... ann.
1884 Holdsworth, E. W. H., F.L.S., F.Z.S., 84, *Clifton Hill, St. John's Wood, N.W.*.................................. ann.
1889 Howell, Mrs. F. Bullar, *Ethy, Lostwithiel* .... ann.
1887 Howes, Prof. G. Bond, F.L.S., *Science and Art Department, South Kensington* .... ann.
1884 Hudleston, W. H., M.A., F.R.S., 8, *Stanhope Gardens, South Kensington, S.W.* .... ann.
1885 Hurst, C. Herbert, Ph.D., *Owens College, Manchester* .... C.
1885 Hurst, Walter, B.Sc., *Owens College, Manchester*.......................... ann.
1884 Huxley, Prof. T. H., LL.D., F.R.S., 4, *Marlborough Place, Abbey Road, N.W.* £31

1891 Indian Museum, Calcutta, per H. S. King & Co., 65, *Cornhill* ...... ann.
1888 Inskip, Capt. G. H., R.N., 22, *Torrington Place, Plymouth* .... ann.

1890 Jackson, C. L., *Hill Fold, Bolton* .... ann.
1885 Jackson, W. Hatchett, M.A., F.L.S.. *Pen Wartha, Weston-super-Mare* .... ann.
1887 Jago-Trelawny, Major-Gen., F.R.G.S., *Coldrenick, Liskeard*............ C.
1885 James, C. H., *Ingleside, Mutley, Plymouth* .... ann.
1890 Jenkins, William, *Ocean Collieries, Treorgy, Glamorganshire*......... ann.
1889 Jennings, Wm. Henry, 58, *Emma Place, Stonehouse*............ ann.
1890 Johnson, Prof. T., B.Sc., F.L.S., *Royal College of Science, Dublin*... ann.
1890 Jones, W. V., 49, *George Street, Plymouth* .... ann.
1892 Joshua, Mrs., 57, *Cadogan Square, S.W.* .... ann.

1884 Kellock, W. B., F.L.S., F.R.C.S., *Stamford Hill, N.* .... ann.
1884 Kent, A. F. S., 33, *New Street, Salisbury* .... ann.

1885 Langley, J. N., F.R.S., *Trinity College, Cambridge*............ C.
1888 Latter, O. H., *Charterhouse, Godalming, Surrey* .... ann.
1885 Lea, A. S., M.A., *Trinity College, Cambridge* .... ann.
1884 Lewis, George, 88, *Portland Place, W.* .... ann.
1888 Lloyd, Fred. H., 5, *Gertrude Terrace, Exmouth* .... ann.
1884 London, The Lord Bishop of, *The Palace, Fulham, S.W.*............ ann.
1888 Lopes, The Rt. Hon. Sir Massey, Bart., *Maristowe, Roborough, South Devon* .... ann.
1884 Lovell, Miss Matilda S., *Fairlawn, Swanmore, Ryde* .... ann.
1887 Lundgren, F. H., 29, *St. Bartholomew's Road, Camden Road, N*...... ann.

1885 Macalister, Prof. A., F.R.S., *St. John's College, Cambridge*............ ann.
1884 Mackrell, John, *High Trees, Clapham Common, S.W.* .... C.
1886 MacMunn, Charles A., *Oak Leigh, Wolverhampton* .... ann.
1889 Makovski, Stanislaus, *Fairlawn, Red Hill* .... ann.
1885 Marr, J. E., M.A., *St. John's College, Cambridge*............ C.
1884 Marshall, Prof. A. Milnes, M.D., D.Sc., F.R.S., *The Owens College, Manchester* £25
1884 Mason, Philip Brookes, *Burton-on-Trent*............ ann.
1884 McAndrew, James J., *Lukesland, Ivy Bridge, South Devon* .... ann.
1884 McIntosh, Prof. W. C., F.R.S., 2, *Abbotsford Crescent, St. Andrews, N.B.* .... C.
1884 Michael, Albert D., *Cadogan Mansions, Sloane Square, S.W.*......... C.
1885 Mitchell, P. Chalmers, B.A., *McLean Place, Dumfermline* .... ann.
1885 Mocatta, F. H., 9, *Connaught Place, W.*............ C.
1886 Mond, Ludwig, 20, *Avenue Road, Regent's Park, N.W.*............ C.
1884 Moore, Thomas John, C.M.Z.S.L., Curator Free Public Museum, *Liverpool*............ ann.
1884 Morgan, Prof. C. Lloyd, *University College, Bristol*............ ann.
1891 Morgans, Thomas, *The Guildhall, Bristol* .... ann.
†1889 Morley, Earl of, *Prince's Gardens, S.W.* .... ann.
1885 Morris, John, 13, *Park Street, Grosvenor Square, W.*............ £21
1885 Morrison, Alfred, 16, *Carlton House Terrace* .... £52 10*s.*

†1884 Newton, Prof. Alfred, M.A., F.R.S., *Magdalene College, Cambridge*... £20
†1884 Norman, Rev. Canon, M.A., D.C.L., F.R.S., *Burnmoor Rectory, Fence Houses*........ ann.

1885 Oliver, Prof. F. W., *Royal Gardens, Kew*........ ann.
1884 Ommanney, Admiral Sir Erasmus, C.B., F.R.S., 29, *Connaught Square, W.*........ ann.

1885 Paget, Sir James, Bart., F.R.S., 1, *Harewood Place, Hanover Square, W.*........ C.
1884 Parsons, Chas. T., *Norfolk Road, Edgbaston, Birmingham* .... ann.
1891 Pass, A. C., 15, *Upper Belgrave Road, Durdham Down, Bristol* ...... ann.
1888 Peek, Sir Henry W., Bart., F.Z.S., *Wimbledon House, Wimbledon*... C.
1888 Pennsylvania, University of, *Philadelphia, U.S.A.*........ ann.
1885 Phillips, Chas. D. F., M.D., 10, *Henrietta Street, Cavendish Square, W.* .... C.
1887 Phipson, Mrs., *Cumballa Hill, Bombay*........ ann.
1885 Pochin, H. D., *Bodnant Hall, Eglwysbach, Denbighshire* .... C.
1884 Potter, Michael C., M.A., *Herbarium, New Museums, Cambridge* ... ann.
1884 Powell, Thos. Harcourt, *Drinkstone Park, Woolpit, Bury St. Edmunds* .... C.
1886 Power, Henry, F.R.C.S., 37A, *Great Cumberland Place, W.* .... ann.
1888 Prance, C. R., M.D., 18, *Princess Square, Plymouth* .... ann.
1885 Pritchard, Urban, 3, *George Street, Hanover Square, W.* .... ann.
1884 Pye-Smith, P. H., M.D., 54, *Harley Street, W.* .... C.

1884 Radford, Daniel, *Mount Tavy, Tavistock* .... ann.
1884 Ralli, Mrs. Stephen, *Cleveland House, Clapham Park* £30
1885 Ransom, W. B., *Trinity College, Cambridge* .... C.
1888 Rawlings, Edward, *Richmond House, Wimbledon Common*........ ann.
1887 Riley, W., *Newcastle House, Bridgend, Glamorganshire*........ ann.
1892 Robinson, Miss M., *University College, London, W.C.* .... ann.
*1891 Rollit, Sir Albert, M.P., *Dunster House, Mark Lane, E.C.* .... ann.
1884 Rowe, J. Brooking, F.S.A., F.L.S., *Mulgrave Street, Plymouth*........ ann.
1891 Rundle, E., *Royal Cornwall Infirmary, Truro*........ ann.
1885 Ruscoe, John, *Albion Works, Henry Street, Hyde, near Manchester*... ann.

1889 Sanford, W. A., *Nynehead Court, Wellington, Somerset*........ ann.
1884 Schäfer, Prof. E. A., F.R.S., *University College, Gower Street, W.C.*... ann.
1888 Scharff, Robert F., Ph.D., *Science and Art Museum, Dublin*........ ann.
*1884 Sclater, P. L., F.R.S., Sec. Zoöl. Soc., 3, *Hanover Square, W.*........ ann.
1884 Sclater, W. L., *Eton College, Windsor* .... ann.
1885 Scott, D. H., M.A., Ph.D., *The Laurels, Bickley, Kent*........ C.
*1884 Sedgwick, A., M.A., F.R.S., *Trinity College, Cambridge* .... C.
1888 Serpell, E. W., 19, *Hill Park Crescent, Plymouth* £50
1885 Sheldon, Miss Lilian, *The Field, Stroud* .... ann.
1884 Shipley, Arthur E., M.A., *Christ's College, Cambridge* .... C.
1886 Shore, T. W., M.D., *The Warden's House, St. Bartholomew's Hospital, E.C.* .... ann.
1889 Simpson, Francis C., *Maypool, Churston Ferrers, R.S.O., S. Devon* ann.

1891 Sinclair, William F., *Bombay Civil Service* ... C.
1884 Skinners, the Worshipful Company of ... £42
1889 Slade, Lieut. E. J. Warre, R.N., *H.M.S. Rodney, Chatham* ... C.
1884 Sladen, W. Percy, Sec. Linn. Soc., 13, *Hyde Park Gate, S.W.* ... ann.
1884 Sowerby, William, *Royal Botanical Society, Regent's Park, N.W.* ... ann.
1884 Spencer, J., 121, *Lewisham Road, Lewisham, S.E.* ... ann.
1888 Spencer, Prof. W. Baldwin, M.A., *University of Victoria, Melbourne* ann.
1884 Spring-Rice, S. E., 9, *Wilton Street, Grosvenor Place, S.W.* ... C.
1884 Stalbridge, The Rt. Hon. Lord, 12, *Upper Brook Street, W.* ... ann.
*1884 Stewart, Prof. Chas., P.L.S., *Royal College of Surgeons, Lincoln's Inn Fields, W.C.* ... ann.
†1884 Sutherland, The Duke of, K.G., *Stafford House, St. James', S.W.* ... C.
1888 Swain, W. Paul, M.R.C.S., *The Crescent, Plymouth* ... ann.

1889 Taylor, Thomas George, 6, *St. Mary Street, Stonehouse* ... ann.
1884 Thompson, Prof. D'Arcy W., *University College, Dundee* ... ann.
1890 Thompson, Herbert, B.A., 35, *Wimpole Street, W.* ... ann.
1884 Thornycroft, John I., *Eyot Villa, Chiswick Mall* ... ann.
1888 Thurston, Edgar, *Government Central Museum, Egmore, Madras* ... ann.
1888 Tripe, Major-General, 3, *Osborne Villas, Stoke, Devonport* ... ann.
1889 Tweedy, W. Gage, 8, *Athenæum Terrace, Plymouth* ... ann.
1885 Tylor, E. B., D.C.L., F.R.S., *Museum House, Oxford* ... ann.

1884 Upcher, Henry R., *Sherringham, Cromer* ... ann.

1891 Vachell, C. J., M.D., 38, *Charles Street, Cardiff* ... ann.
1888 Vallentin, Rupert, 18, *Kimberley Road, Falmouth* ... ann.
1891 Vaughan, Henry, 28, *Cumberland Terrace, N.W.* ... ann.
1884 Venning, Mrs., 3, *Wingfield Villas, Stoke, Devon* ... £50
1884 Vines, Professor Sydney H., M.A., D.Sc., F.R.S., *Botanical Gardens, Oxford* ... ann.
1888 Vosper, Samuel, *Stonehouse, Plymouth* ... ann.

1884 Walker, Alfred O., *Nantyglyn, Colwyn Bay, N. Wales* ... ann.
1884 Walker, P. F., 36, *Princes Gardens, S.W.* ... ann.
†1884 Walsingham, Lord, F.R.S., *Merton Hall, Thetford* ... £20
1890 Waterhouse, Edwin, *Feldemore, Dorking* ... ann.
1888 Weiss, F. Ernest, 3, *Grosvenor Terrace, Withington, Manchester* ... ann.
1890 Were, Nicholas, 9, *Osborne Place, Plymouth* ... ann.
1891 Wildy, A. G., 13, *Furnival's Inn, E.C.* ... ann.
1890 Wilson, J. B., *Grammar School, Geelong, Victoria* ... ann.
1884 Wilson, Scott B., *Heather Bank, Weybridge Heath* ... C.
1884 Woodall, John W., M.A., F.G.S., *St. Nicholas House, Scarborough* ... ann.
1888 Woods, G. W., F.I.C., F.C.S., *Ballagawne, Riggindale Road, Streatham, S.W.* ... ann.
1884 Woollcombe, W. G., M.A., F.R.A.S., F.L.S., 101, *King Edward's Road, S. Hackney, London* ... ann.

1891 Young, Sydney, M.D., *University College, Bristol* ... ann.

IV.—Associate Members.

1889 Alward, George, 11, *Hainton Street, Great Grimsby.*
1889 Caux, J. W. de, *Great Yarmouth.*
1889 Dannevig, Capt. G. M., *Arendal, Norway.*
1889 Dunn, Matthias, *Mevagissey.*
1889 Olsen, O. T., F.L.S., F.R.G.S., *Fish Dock Road, Great Grimsby.*
1889 Ridge, B. J., 3, *Gainsboro' Place, Mutley, Plymouth.*
1890 Roach, W., *Sussex Street, Plymouth.*
1889 Shrubsole, W. H., 62, *High Street, Sheerness-on-Sea.*
1889 Sinel, Joseph, 2, *Peel Villas, Cleveland Road, Jersey.*
1890 Spencer, R. L., *L. and N.W. Depôt, Guernsey.*
1890 Wells, W., *The Aquarium, Brighton.*
1889 Wilcocks, J. C., *May Cottage, Shoreham, Sussex.*
1890 Wiseman, Fred., *Buckland House, Paglesham, Rochford, Essex.*

Henry Nottidge Moseley, Esq., F.R.S.

We regret to record the death, on November 10th last, of H. N. Moseley, M.A., LL.D., F.R.S., &c., Linacre Professor of Human and Comparative Anatomy in the University of Oxford, one of the earliest and warmest supporters of the Association. He was one of the speakers at the Foundation Meeting in 1884, and was Chairman of the first Council.

Director's Report.

The general condition of the Laboratory since the date of my report in the last number of the Journal calls for little mention. Some slight repointing of the walls and glazing has been necessary to keep out the winter rains, and the overhaul of one of the gas engines deemed desirable for the proper continuation of pumping without loss of gas. In other respects the entire building continues to render every satisfaction.

The work done by the various members of the Staff will be most readily estimated by the perusal of the several papers written by the members, and need not be mentioned in detail by me.

In my last report I made mention of the fishery investigations to be carried on by Mr. Holt in the North Sea, stating that in this Journal I would probably be in a position to state upon what lines the observations had been begun.

Since the issue of last number, another Fishery Conference has been held at Fishmongers' Hall under the auspices of the National Sea Fisheries Protection Association. At this conference the capture and sale of undersized fish was again under discussion, and again a resolution was passed defining, to the satisfaction of most of those present, the sizes below which soles, plaice, turbot, &c., should not be captured and sold. The discussion, as well as the resolution, proved abundantly to anyone at all acquainted with the sizes at which the various food fishes first spawn, that the sizes were arrived at purely with a view to keeping *undersized* fish out of the market, and without any reference to the maturity or immaturity of these fish. It showed most clearly how much information is yet needed by those who are personally interested in the fish trade, and who draw up measures for its regulation, and how important is the work undertaken by the Marine Biological Association in that area of the North Sea most frequented by trawlers from Grimsby, Hull, Great Yarmouth, and Lowestoft, as well as from other countries.

The following is a brief sketch of the work at present being carried on by Mr. Holt, who contributes, in another part of this Journal, a preliminary report on his methods of procedure.

The objects are—

1. To prepare a history of the North Sea Trawling Grounds, comparing the present condition with the condition say twenty or thirty years ago, when comparatively few boats were at work.

2. To continue, verify, and extend observations as to the average sizes at which the various food fishes become sexually mature.

3. To collect statistics as to the sizes of all the fish captured in the vicinity of the Dogger Banks and the region lying to the eastward, so that the number of immature fish annually captured may be estimated.

4. To make experiments with beam trawl nets of various meshes, with a view to determine the relation, if any, between size of mesh and size of fish taken.

It will be seen at once that, for one person, a very great amount of work is involved, and that before reliable data can be collected on all four points considerable time must elapse. In Mr. Holt's early reports, therefore, it has been thought advisable not to treat each heading in detail, since one season of the year may be more suitable for collecting information on one point than on another, but rather simply to state the results of work accomplished. During this, the spawning season, for instance, most attention must necessarily be given to heading No. 2 ; hence, in Mr. Holt's present report, the relation of size to immaturity is principally mentioned.

Already the information collected shows many points of interest. From the work of a similar nature, carried on by Mr. Holt himself in Ireland, from Dr. Fulton's results, published in the Scotch Fishery Board's Reports, and from observations made at Plymouth, it is obvious that a very considerable variation takes place in the sizes at which fishes become sexually mature in different localities ; and it is probably not too much to say that as surely as legislation will have to be resorted to for the preservation of fish until they have spawned, so surely will the matter have to be studied for each coast separately. In localities where there is no foreign element introduced, or where only English boats fish in territorial waters, the Sea Fishery District Committees will naturally be looked to for the proper conduct of affairs, and it will therefore be highly necessary that each committee should understand the guiding principles of natural history involved ; but where, as in the North Sea, foreign fishermen compete with those from this country, International Legislation must of necessity be brought about, otherwise the outcry, at present so loudly heard, will not cease, and the market for little fishes which have not spawned being kept open, the fishing grounds will be depleted, and the east coast industry ruined.

I have made reference to the Fishery Conference, and its resolu-

tion as to the sizes under which fish should not be allowed to be taken. I do not wish for a moment to have it supposed that I undervalue the importance of such conferences, my attendance on the 24th, 25th, and 26th February last was sufficient to dispel any such idea; what I mean to indicate is, that when a measure is proposed, which must necessarily start from a knowledge of the spawning periods and life history of fish, a large body of men who have no such knowledge—although they may have worked among fish all their lives—must necessarily deal with the question from a trade point of view only.

I do not intend to go further into the question at this juncture, but only to point out that the two points stated above have lately been seen to be widely apart.

The experiments on the production of an artificial bait have been continued. The question still presents serious difficulties, and a decided success has not yet been attained. Mr. Hughes, the chemist who undertook this inquiry, has now left the Laboratory, but contributes a final paper to this number of the Journal.

At first sight, the production of an attractive, easily-procured, and inexpensive bait does not seem a serious problem; but, as several who have made the attempt have found, the construction of some substance of suitable consistency in which to convey the attractive elements, is a problem calling for considerable ingenuity, patience, and perseverance.

The fishermen in this locality still suffer from a great scarcity of bait. Night after night boats are compelled to remain in harbour because the crew have found it impossible to procure bait; and I am told that the way in which one or two crews succeed is by rowing about during the night as the trawlers are coming in, buying up small quantities of shell-fish here and there till sufficient is collected. It is a laborious and often very expensive method, and certainly calls for some alteration. We still hope, therefore, by continuing the artificial bait experiments, to be able to produce some satisfactory results.

At the same time I cannot but think that if the rights of the foreshores can be sufficiently guarded, extensive bait cultivation might be carried out in certain suitable localities. It is successfully done in several parts of Scotland, although there the supply is far short of the demand, and I see no reason why it should not be equally well done in England.

On the 27th of January, owing to the repeated breaking down of the steam-launch, I was obliged to report to Council that it was absolutely necessary to have some more reliable craft with which to carry on our sea work. The Association not being able to afford

the heavy cost of keeping up a steamer of the size required, it was thought advisable to purchase a sailing trawler, in which trips of many days' duration could be made. There are many localities of great interest which should be visited, but which are impossible to reach unless by employing the expensive method of hiring a special vessel; and for carrying on our fishery investigations some large boat, capable of going where any other fishing-boat can go, is of inestimable importance. I have made many inquiries, and have looked at several boats, but, so far, have not found a vessel suitable both in condition and in price.

Mr. Garstang, formerly Assistant to the Director, who left Plymouth to take up a research Fellowship at the Owens College, Manchester, has again been offered an appointment on the Staff. He has accepted, and his appointment will date from May. His duties will consist chiefly in superintending the collection, preservation, and identification of specimens.

The demand for specimens for use in laboratories and museums throughout the country increases, and requires constant attention. We can supply specimens which, in very many cases, could not otherwise be obtained. The proper preservation of certain classes of soft animals is in itself an art developed during the last fifteen years, almost entirely by the persevering efforts of Sig. Lo Bianco, of Naples. Within the past year these methods have been published, and with practice it is hoped that the specimens sent out from the Plymouth Laboratory may gradually gain the character so long possessed by the Naples specimens alone.

At present all the preserving is done by the Laboratory Assistant, Mr. Joseph Walker, and we venture to think that although our results are not yet sufficiently fine to be quite satisfactory, a very decided advance has been made.

Quite recently a new price list of zoological specimens has been issued. This is the second list, and from the experience gained by the first, it has been found necessary to raise very many of the prices. If, however, the quality of material produced is better, we do not think that any of the prices will be found to be too high, and it has been our aim to keep the prices of animals most commonly used for teaching purposes, and therefore ordered in large quantities, as moderate as possible.

During the last few months I have received communications from several important centres on the east, west, and south coasts of England, asking for information relating to the construction of sea-fish hatcheries and marine laboratories.

The idea that some practical benefit is to be derived from such establishments seems to be gaining ground. In one or two locali-

ties definite steps are already being taken to form small stations of this kind; and as this Association and its Laboratory are naturally looked to as being an institution founded on a broad and sound basis, proposals have been made in one or two instances to place such small hatcheries under our supervision. Everyone knows what has been accomplished by the hatching and rearing of salmon and trout in our rivers, and now that the hatching of sea fish is making such strides, it is but natural that the attempt should be made to benefit our sea fisheries in a like manner. Norway, the United States of America, and Newfoundland have set us the example; and as the success attained becomes known in this country our fishermen may learn to believe that, as the agriculturist cannot expect to reap a harvest on ground where no seed has been sown, neither can he, considering the immense increase of fishing craft within recent years, expect the same fishing grounds continually to yield abundance. At present, when one district ceases to yield a remunerative return, the only idea present to the mind of the fisherman is to find out some new or little fished ground. But now, in the case at least of Great Britain, the limit to this method has been fairly well reached, and we must look to the preservation of spawning fish and the protection of the young, in order to keep up the balance of nature.

Amongst the Notes and Memoranda will be found a few extracts from a recently published Newfoundland Report showing what is being done in that country.

W. L. CALDERWOOD.

On a Species of Siphonophore observed at Plymouth.

By

J. T. Cunningham, M.A.

Last autumn the occurrence of a small Siphonophore in the produce of the surface tow-nets attracted my attention. I first noticed it in the contents of a small net, worked five miles south of the Eddystone, on September 12th, and afterwards it was obtained in great abundance close to the Plymouth Breakwater, and even inside the Sound. It was brought in numbers to the Laboratory almost every day up to about the middle of October, but after the end of that month it was not seen again.

This Siphonophore was a Monophyid, and its single nectocalyx was from 3 to 6 or 7 mm. in length. Its appearance as a whole when slightly magnified is represented in Figs. 1 and 2, p. 213.

An elaborate description of the organism would be impossible without a detailed explanation of the structural features which are common to the family Monophyidæ, and which distinguish that family from other divisions of the Siphonophora. Such a detailed explanation would be quite superfluous, since a reference to Haeckel's Report on the Challenger Siphonophora, p. 125, and elsewhere, will at once afford a lucid and definite analysis of the whole class, and enable anyone to follow the discussion of the identity and position of the species here considered. I shall therefore confine myself to the question of identification, using the terms adopted by Haeckel for the various organs.

It will be seen at once, then, that the form belongs to the genus Muggiæa, the definition of which is "Monophyidæ with an angular pyramidal nectophore, and a complete infundibular hydrœcium in its ventral side. Bracts spathiform or conical, with a deep ventral groove, a bevelled basal face, and a simple ovate phyllocyst." I have not figured the bracts, nor have I been able to make a thorough

examination of them, but have seen enough of them to know that they do not invalidate the identification of the genus.

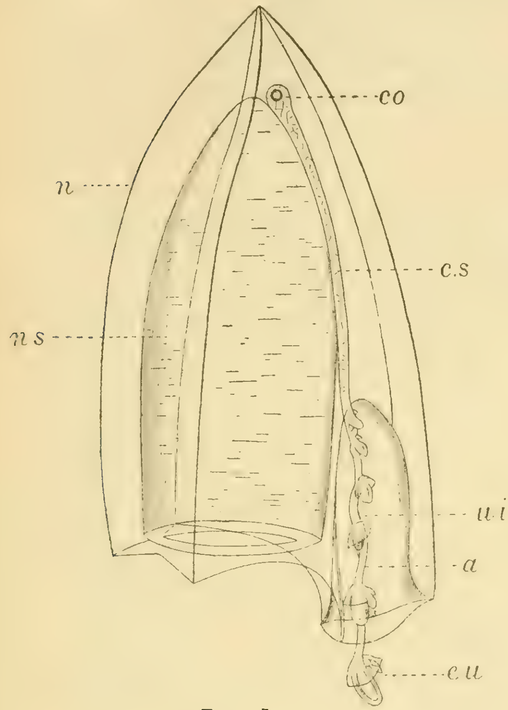


Fig 1

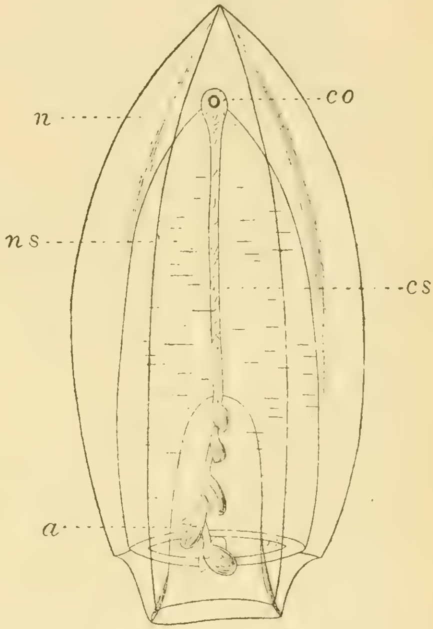


Fig 2

FIG. 1.—Muggiæa atlantica, seen from the right side.

FIG. 2.—The same from the ventral side.

a, siphosome or common tubular stem, bearing *eu*, cormidia or groups of zooids at intervals; *co*, oleocyst; *cs*, somatocyst; *n*, nectocalyx; *ns*, nectosac or cavity of the nectocalyx; *ui*, hydrœcium, cavity from the apex of which the siphosome depends.

Only one species of Muggiæa has been adequately investigated; two others are mentioned by Haeckel, but they have not been sufficiently described. The first species is described by Dr. Carl Chun in a paper in the Sitzungsberichte der k. preuss. Akad. der Wissenschaften, translated in Ann. and Mag. Nat. Hist., 5th series, vol. xi, p. 153. It was originally described as *Diphyes Kochii*, and afterwards as Muggiæa. Chun adopts the name *Muggiæa Kochii*. This species was obtained at Trieste in the Adriatic, and by Chun at Malaga on the coast of Spain. It is obviously different from the Plymouth species, for although its shape is similar, its size about the same, and the ridges of the nectocalyx are smooth, the hydrœcium is much shorter, and the somatocyst only extends to half the height

of the nectosac; whereas in the Plymouth species the hydrœcium extends to one third the height of the nectosac, and the upper end of the somatocyst is above the apex of the latter.

The third species recognised by Haeckel is one described by Huxley in his Ray Society monograph on the Oceanic Hydrozoa as *Diphyes Chamissonis*. This form was obtained in the Pacific Ocean, and is distinguished by the broader, shorter form of nectocalyx, and by the denticulation of its ridges.

Haeckel's second species is one observed by himself in the Canary Island, Lanzerote, which he says differs from *M. Kochii* mainly in the size of the conical hydrœcium, the top of which attains to half the height of the nectosac. Haeckel has nowhere given a figure nor any more detailed description of this species. As for its name, he says it may *retain* the name *Muggiæa pyramidalis,* but the choice of this name seems to have been due to a mistake. In the translation of Chun's paper in the Ann. and Mag. Nat. Hist., he points out that the young *Muggiæa Kochii* when first developed from the egg has not the characters of Muggiæa, but of the genus Monophyes; the nectocalyx is rounded, not pyramidal, and the hydrœcium is an open groove, not a closed cavity. Chun calls this stage *Monophyes primordialis,* which Haeckel quotes as *Monophyes pyramidalis*. On the other hand, the Eudoxia stage of *Muggiæa Kochii* was described by Will under the name *Ersæa pyramidalis*.

Now, although it seems to me extremely probable that the form observed by Haeckel at the Canary Islands was of the same species as that obtained at Plymouth, it is not certain. The most characteristic feature about the Plymouth form seems to me to be the great length of the somatocyst and the position of the oleocyst above the apex of the nectosac. I wrote to Professor Haeckel on the subject, and he replied that he was unable after so many years to ascertain whether his species and mine were the same, as he had neither specimens nor drawings which sufficiently exhibited the test structures. At the same time I think it is inconvenient to use for another species either of the names *pyramidalis* or *primordialis,* which have been applied to stages of *Muggiæa Kochii*. I have therefore to find a new name for the species occurring at Plymouth, which may or may not have a range extending to the Canary Islands, and will call it *M. atlantica*. There is one point to be noted which makes it very probable that the Canary Island form and the English form are the same, namely, that in the former according to Haeckel the hydrœcium extends to half the height of the nectosac, and in the latter its relative height is nearly as great, so that in the Canary Island form the somatocyst may extend as in the English to the apex of the nectosac.

The form I have described was also noticed at Plymouth by Mr. G. C. Bourne, who states in his report of his cruise in H.M.S. "Research," this Journal, vol. i, No. 3, that he also obtained it off the south-west coast of Ireland, and that it seems to be the *Muggiæa Kochii* of Chun and Haeckel. I have indicated above the points by which it is definitely distinguished from *Muggiæa Kochii.*

In the paper already cited, Chun gives a detailed account of the interesting and complicated changes which he discovered to take place in the life-history of *Muggiæa Kochii.* The egg first develops into a stage resembling Monophyes, in which the nectocalyx is smooth and without ridges. The characteristic pyramidal nectocalyx then develops and separates, carrying the siphosome with it. The cormidia or eudoxomes, when fully developed on the tubular stem or siphosome, become free, and continue to live as independent organisms or colonies, which were originally described under the name *Eudoxia Eschscholtzii.* The Eudoxia bears a genital calyx resembling a nectocalyx in shape, and this produces ova or spermatozoa. Each Eudoxia is unisexual, but produces several genital calyces in succession, all of the same sex. From the egg of the Eudoxia develops the Monophyes-like larva and the series of stages recommences. Probably the *Muggiæa atlantica* has a similar life-history, but I was unable to make a more complete study of it, partly because I had other work to attend to, partly because I could only obtain pelagic material when the total results of the day's collecting were brought in somewhat late in the afternoon. The specimens as brought to me were always in the condition shown in my figures, only a short basal portion of the siphosome remaining attached to the nectocalyx. Detached eudoxomes were present in the bottles, but in a somewhat damaged condition.

North Sea Investigations.

By

Ernest W. L. Holt,
Naturalist on Staff in charge of Investigations.

The reasons which induced the Association to undertake this work, and the nature of the investigations proposed to be carried out, will be familiar to readers of this Journal (see vol. ii, No. 2, p. 88), and need not be here recapitulated. I shall, therefore, confine myself to a brief account of such progress as has already been made.

Grimsby was selected as head-quarters, as being the port from which the largest number of boats work, and, in fact, the head-quarters of the North Sea Trawling Industry. A local body, the Marine Fisheries Society, has for the last few years been carrying on work in Grimsby, principally in connection with the culture of sea fish, and for that purpose has erected an aquarium or hatchery at Cleethorpes, a small watering-place and fishing village on the outskirts of the town. It was felt that it would be of great advantage if the Association could secure the co-operation and assistance of this Society, and communications accordingly passed between the Director and Mr. O. T. Olsen, Secretary of the Society and also a member of the Association, and to whose energy and enthusiasm the foundation and subsequent success of the Society are in great measure due. As a result the Society at once promised every assistance in their power, and furthermore placed their premises at Cleethorpes at my disposal for such work as could be most conveniently carried on there. The hatchery contains glass and slate tanks of various sizes, with apparatus for circulating the water, and its reservoir is connected with the sea pump of the adjacent public baths, so that direct communication with the Humber can be established at any time. There is an ample supply of hatching boxes of various patterns, and machinery for setting them in motion after Captain Dannevig's method. A museum and office are attached, and the Society has further been at the trouble and expense of erecting a small laboratory for my accommodation.

An arrangement has also been arrived at whereby I secure the services of the Society's care-taker for such purposes as they may be required, the Association bearing half the expense of his salary.

I arrived at Grimsby on the 1st of January, and a certain amount

of time was necessarily taken up in arranging preliminaries and settling the method of procedure.

At present it seems advisable to confine my remarks to describing the system on which work is carried out, deferring any report on the results until such time as they shall be complete.

I visit the market every morning in order to obtain fish for investigating the condition of the reproductive organs at different sizes. The quantity that can be got is, of course, regulated by the price, which during the first two months of the year has been remarkably high. It has, therefore, been impossible to devote much attention to soles, but it may be expected that during the next few months the price will become more reasonable, while the incidence of the spawning period will be of advantage. In the case of turbot and brill, which are brought to market ready gutted, it is possible to make the necessary examination without injuring the saleable quality of the fish, and for this purpose Mr. Bulpit, a salesman in the market, has kindly allowed me access to any fish that come to his stall. The removal of a small piece of the testis or ovary, for microscopical examination in doubtful cases, causes no injury. The fish purchased are conveyed by the attendant to the hatchery, where, with the necessary apparatus at hand, careful observations are subsequently made. Details as to the number of fish examined will be found annexed.

Incidentally to this investigation a good deal of information is obtained as to the spawning period of the prime fish on the different grounds, and much can also be learnt by observing the operations at the gutting tables, where the coarser kinds of fish are cleaned for transmission or curing.

Considerable difficulty has been encountered in obtaining accurate statistics as to the distribution and annual destruction of immature fish on the different grounds. The weight of fish captured is accessible, since Mr. W. Hood, statistician to the Board of Trade at this port, kindly allows me to inspect his books, and by this means, from general observations of the fish in the market at different seasons, a computation can be made; but its value is at best doubtful. Obviously statistics, to be reliable, must be collected at sea, and for this purpose I have endeavoured to enlist the assistance of as many skippers of trawling vessels as possible, and have been helped by the influence of Mr. Olsen, Mr. G. L. Alward, and others at Grimsby, and have been promised assistance from other parts of the coast. At first I tried entrusting such skippers as would take them with note-books, lists of sizes, and measures, but soon found that, although in a few cases the results were satisfactory, this method of keeping records was too great a tax upon the time of

busy men. I have therefore had forms printed, which require little beyond the filling in of figures, with the best results. It takes time to extend the operations to a sufficiently large scale, as it is only the most intelligent amongst the community who readily interest themselves in matters of this kind. I am able to collect a certain amount of information myself at sea, as Mr. G. L. Alward has been most kind in procuring me a berth whenever I want it on any of the vessels belonging to the various companies with which he is connected. So far I have only made two trips, as fishing has hitherto been confined to grounds where small fish are not plentiful. The season for the grounds on the eastern side of the North Sea is only just opening.

By inducing skippers to bring me in all the "rubbish" from the last haul of a trip, with careful data as to position and soundings, it has been possible to collect considerable information as to the fauna of the different grounds. Objects of special interest are also usually brought to me.

For investigating the relation of size of mesh to size of fish caught, I have caused a number of cod ends of different sized mesh, braided in different ways, to be prepared. These can be easily laced on to any trawl, and as the cod end is the part of the net in which the opportunity of escape, if any, presents itself to the fish, the object desired can be gained in this way at a great saving of expense. Mr. G. L. Alward has most generously presented the Association with a trawl, 24 feet beam, which can be used in connection with these cod ends. So far no opportunity of testing them has occurred, for want of a boat, but I have now made arrangements for making the first series of experiments at an early date.*

The following are found convenient limits for dividing large and small fish :

Turbot	17 inches.	Cod	20 inches.
Brill	15 "	Haddock	10 "
Sole	12 "	Whiting	8 "
Lemon Sole	10 "	Grass Whiting = Pollack	18 "
Plaice	17 "	Coal-fish	20 "
Halibut	23 "	Hake	24 "
Witch	12 "	Ling	24 "
Megrim	12 "	Tusk	16 "
Sand dab	6 "	Cat-fish	20 "
Long Rough Dab	6 "	Gurnard	9 "
Flounder	7 "	John Dory	14 "

The fish enumerated in the returns are selected on account of their proximity to the size limits.

* Since this went to press I have made one trial of the nets, with results of some interest.

Return of Fish examined during Month of January, 1892.

Locality from which fish derived.	Name of fish.	No. caught.	No. received from other boats.	No. examined.	No. males.	No. females.	No. large.	No. small.	No. immature.	No. approaching ripeness.	No. ripe.	No. spent.
North Sea	Turbot . . .	—	3	3	1	2	0	3	2♀	1	0	0
"	Brill . . .	—	7	7	1	6	0	7	5♀	1♂ 1♀	0	0
"	Plaice . . .	—	65	65	22	43	13	52	11♂ 31♀	5♂ 4♀	4♂ 6♀	1♂ 2♀
"	Poledab or Witch .	—	4	4	0	4	4	0	0	4♀	0	0
"	Cod . . .	—	2	2	1	1	1	1	1♀	1♂	0	0
"	Haddock . .	—	7	7	1	6	7	0	0	1♂ 6♀	0	0

Return of Fish examined during Month of February, 1892.

Locality from which fish derived.	Name of fish.	No. caught.	No. received from other boats.	No. examined.	No. males.	No. females.	No. large.	No. small.	No. immature.	No. approaching ripeness.	No. ripe.	No. spent.
North Sea	Turbot . . .	—	39	39	19	20	26	13	3♂ 5♀	16♂ 15♀	0	0
"	Brill . . .	—	17	17	6	11	10	7	1♀	6♂ 10♀	0	0
"	Sole . . .	—	44	44	22	22	9	35	1♂ 11♀	21♂ 11♀	0	0
"	Lemon Sole . .	—	9	9	3	6	8	1	1♀	3♂ 5♀	0	0
"	Plaice . . .	—	51	51	15	36	32	19	3♂ 17♀	5♀	9♂ 5♀	3♂ 7♀
"	Halibut . . .	—	7	7	3	4	1	6	2♂ 4♀	1♂	0	0
"	Common Dab . .	—	16	16	8	8	9	7	2♀	4♂ 6♀	4♂	0
"	Long Rough Dab .	—	2	2	0	2	2	0	0	0	2♀	0
"	Cod . . .	—	11	11	5	6	9	2	3♂ 4♂	1♂ 1♀	1♂	0

Return of Fish examined during Month of March, 1892.

Locality from which fish derived.	Name of fish.	No. caught.	No. received from other boats.	No. examined.	No. males.	No. females.	No. large.	No. small.	No. immature.	No. approaching ripeness.	No. ripe.	No. spent.
North Sea	Turbot . . .	—	12	12	8	4	6	6	1♂ 4♀	7♂	0	0
"	Plaice . . .	—	4	4	0	4	0	4	2♀	0	0	2♀
"	Common Sole . .	—	9	9	7	2	4	5	0	6♂ 2♀	1♂	0
"	Lemon Sole . .	—	32	32	18	14	28	4	6♀	8♂ 6♀	5♂	5♂ 2♀
"	Common Dab . .	—	36	36	24	12	36	0	0	12♂ 4♀	12♂ 4♀	0
"	Long Rough Dab .	—	1	1	0	1	1	0	0	0	1♀	0
"	Whiting . . .	—	17	17	10	7	16	1	1♀	9♂ 4♀	1♂ 2♀	0
"	Tusk . . .	—	3	3	0	3	3	0	2♀	1♀	0	0
"	Grey Gurnard .	—	51	51	24	27	50	1	1	21♂ 24♀	2♂ 2♀	0

Further Experiments on the Production of Artificial Baits.

By

Frank Hughes.

Since the publication of the last paper a number of experiments have been made in connection with the Bait question. The object aimed at was to obtain some material which would serve as a medium for the application of some or other of the extracts prepared by the methods given in the previous report. A number of common substances were tried without success. The majority were either not sufficiently porous, or, if possessing that qualification, they lacked that strength and toughness which is absolutely necessary in a bait which must lie in the water for some hours.

It is this length of time which renders such materials as sponge, however fine, quite useless, since no extract, even if very much thickened, will remain in a piece of sponge more than a few minutes. Mr. Bateson in his report on this subject suggested the use of China clay ; I tried a number of experiments with this, both dried and soft. In the latter case disintegration occurred at once, and the dried clay did not absorb sufficient extract to render it attractive ; besides this, fish always reject any hard substance, even if it be made attractive with the smell of a favourite food. A somewhat promising material was obtained by boiling down skate skins until they were quite soft, and pressing them into blocks. The large amount of gelatine in these skins caused the fibres to adhere, forming a compact mass. This was somewhat porous and elastic, and took up a considerable amount of extract, but, like a number of other gelatine preparations, would not withstand the prolonged action of the water. A number of experiments were tried with this material, but no mixture could be obtained which would remain unacted on by water for a sufficient time. Other substances, such as gums, were tried, but without success.

Throughout my experiments I have never found any substance at all attractive to the conger other than the extracts, &c., prepared from pilchard, squid, or whelks; these were always attractive, particu-

larly the squid and pilchard preparations. It seems unlikely that anything other than these should be attractive, although there are cases where substances, which animals in the ordinary course of events would not meet with, are extremely attractive. In these cases it would seem likely that there is a strong resemblance between the smell of these substances and that of some favourite food of the animals, although in most cases it is not easy to find.

It will be seen from the above account that the difficulty of finding a "medium" still remains unsolved, and, on that account, the work is still incomplete. If this were discovered, further experiments could be made in the preparation of extracts, and a satisfactory bait would soon result.

At the same time, if nothing is found attractive but preparations of the bait now in use, no very great advantage will be obtained, since the same result could be arrived at by keeping the ordinary bait in a frozen condition. This can be done for a considerable time—six to eight weeks; and the expense, when done on a large scale, would not be very great.

The question appears to me to be one of those which are not so likely to be solved by continuous investigation as by some accidental observation, since it is probable that some substance may be found suitable for the purpose which at first it would appear absurd to use. In the same way some material, other than squid, &c., might be found to be attractive to the fish.

On the Rate of Growth of some Sea Fishes, and the Age and Size at which they begin to Breed.

By

J. T. Cunningham, M.A.

The following paper is to be regarded as the sequel of that published in the preceding number of this Journal, on the rate of growth and distribution of young marine fishes. I am still continuing inquiries of this character, and have now to record the additional results obtained up to the end of March, 1892. I have also described and criticised some of the results of other workers in the same field.

Gadus morrhua, the Cod.

Continuous observations on the growth of marine fishes in captivity have very seldom been made up to the present time. Isolated observations are scattered here and there in Day's British Fishes, and Marion, in the Annales du Musée de Marseille of 1891, has described how he reared the alevins of a species of mullet and of Sargus till they were nearly a year old, but none of these experiments were carried on with the object or with the result of ascertaining definitely the most important facts in the life-history of the species. So far as I have discovered, continuous observations on the growth of fish from the earliest stage almost to the adult condition have only once been attempted before I carried out my own upon flounders, namely, those of Dannevig upon cod. Dannevig's results are described in his Reports upon the Fish Hatchery of Flödevig, published by the *Selskab for de Norske Fiskeriers Fremme*,* and an account of them by Professor Cossar Ewart is to be found in the Fifth Report of the Fishery Board for Scotland for the year 1886. In one respect Dannevig's experiment was superior

* See Aarsberetning, 1886, of Selskabet for de Norske Fiskeriers Fremme, Bergen; Beretning om Flödevigens Udklækningsanstalts Virksomhed i Femaaret, 1883—1888, Arendal, 1889.

to mine, namely, that he hatched his specimens as well as reared them, while mine were obtained at an early stage of life from the sea. I believe that this is the only case in which larvæ artificially hatched from marine pelagic fish eggs have been successfully reared in captivity. This success can only be attributed to the fact that the young fry were turned into a large reservoir of clean sea water. The reservoir was made by building two dams across a narrow rocky gully, opening on to the shores of the inlet on which Flödevig stands. Flödevig is about 6 miles from the town of Arendal on the south coast of Norway. The reservoir was about 43 yards long, 20 yards broad, and 5 yards in greatest depth, and sea water could be constantly pumped into it by means of a steam-engine. The reservoir was like an enclosed portion of the sea-shore, and seaweeds grew in it as on the shore.

Into this large reservoir Dannevig put, on the 3rd May, 1886, about 500,000 cod larvæ hatched on the 27th April. The larvæ when put in were 5 mm. or $\frac{1}{5}$ of an inch in length. Up to the 6th of June their growth was slow, they measured then only 15 mm., and up to this time they refused the artificial food, namely, finely chopped mussels and fish, which was offered to them. After this they began to eat the food thrown into the pond, and their rate of growth rapidly increased. On July 12th, when two and a half months old, they measured 5·5 cm. or nearly 2·2 inches. The subsequent growth will be seen from the following table:

Date.		*Age.*	*Length.*
1886	May 3	6 days	5 mm.
	June 6	1 month 9 days	1·5 cm.
	July 12	2 months 15 days	5·5 cm.
	Aug. 12	3 months 15 days	7·0 cm.
	Sept. 12	4 months 15 days	8·5 cm.
	Oct. 12	5 months 15 days	11·5 to 15·7 cm.
1888	Feb.	1 year 10 months	35·6 to 40·7 cm., 14 to 16 inches.
	Autumn	2½ years	9 to 18 inches.

The last entry in the above list is taken from a separate report by Dannevig on the work done at Flödevig between 1883 and 1888. This report is dated February, 1889, but the paragraph concerning the cod was apparently written in the autumn of 1888. It is there stated that the total number of fish surviving was from 200 to 400, and that they seemed likely to spawn in the following spring. I have not been able to find anything further about these fish in later reports.

Fulton finds the smallest ripe cod to be 20 inches long, and Holt thinks that the smallest ripe female is considerably larger. Dannevig's specimens had not reached 20 inches in two and a half

years, and there is no evidence in his experiment that any specimens spawned at two years of age. In fact, his experiment was made merely with the object of proving that artificially hatched larvæ could grow into adult fish, and he seems to have paid little attention to questions as to the size or age at which sexual maturity is attained. It seems to me probable that, either by reason of the confinement or of insufficient food, the size reached by Dannevig's specimens in two a half years was considerably below the normal size of free individuals of that age.

Dannevig mentions in his Report for 1886 that on the 13th May he placed 5000 newly hatched flounders in the pond or reservoir above mentioned with the young cod; in the translation given by Prof. Ewart, loc. cit., the species is erroneously given as *Pleuronectes limanda,* but Dannevig himself states that *skrubbe,* the word he uses, means *Pl. flesus.* In May, 1888, these flounders had attained a length of 7 or 8 inches, so that some of my captive flounders, described in the following section, though reared in comparatively small tanks, were larger than those kept by Dannevig in a large open-air reservoir. Dannevig says nothing about the spawning of these captive flounders.

Ewart states that Dannevig reared herring in the same reservoir, but I can find no reference to herring in the reports of the latter.

Pleuronectes flesus, the Flounder.

The specimens of this species reared in the aquarium, whose length in the spring of last year was given in my previous paper, were measured again this year when they were about two years old. Their lengths and conditions were as follows:

February 23rd, 1892. Specimens in a table tank 5 feet by 2½ feet in area, by 1 foot 5 inches deep, measured and examined. Total number of specimens 24.

Of these three were ripe males, and one was a female, which though not actually ripe had a well-developed ovary, which would without doubt yield ripe ova this season. The lengths of these were—

Males.		*Female.*
23·3 cm., 9·2 in.	...	21·3 cm., 8·4 in.
22·2 ,, 8·8 ,,		
21·0 ,, 8·3 ,,		

The remaining specimens were all unripe; their sexes were not determined. Their lengths were—

(1) 24·8 cm., 9·7 in.	(8) 17·3 cm.	(15) 14·0 cm.
(2) 20·8 „	(9) 17·2 „	(16) 13·7 „
(3) 20·0 „	(10) 16·7 „	(17) 13·4 „
(4) 19·7 „	(11) 16·4 „	(18) 12·5 „
(5) 19·2 „	(12) 15·7 „	(19) 12·2 „
(6) 18·0 „	(13) 14·5 „	(20) 10·5 „ 4·1 in.
(7) 18·0 „	(14) 14·2 „	

I separated the three ripe males and the ripening female, placing them in another tank, and returned the rest alive to the tank they were taken from.

On March 21st I examined the unripe specimens again, to see if any had become ripe in the interval, but could find no signs of sexual maturity in any of them. Two of them had died in consequence of the handling they underwent on the first occasion. I now took one specimen, the third on the above list, killed it and dissected it. I found it was a female; the ovary was quite small, and showed no signs of reproductive activity. The organ extended only about 1·5 cm. beyond the posterior boundary of the abdominal cavity, and the ova were not separately visible to the eye. It seemed evident that this specimen would not have spawned during the present season.

The other specimens of the same age had been living in a large tank 18 feet by 3½ feet in area, and 2 feet in depth. I emptied this tank on February 24th, and found in it sixty-five flounders. Of these nine were males in a perfectly ripe condition, whose lengths were—

(1) 23·4 cm., 9·2 in.	(4) 21·0 cm., 8·3 in.	(7) 19·8 cm., 7·8 in.
(2) 23·1 „ 9·1 „	(5) 20·8 „ 8·2 „	(8) 17·4 „ 6·9 „
(3) 22·1 „ 8·7 „	(6) 20·0 „ 7·9 „	(9) 16·2 „ 6·4 „

Three were females with large swollen ovaries, not perfectly ripe, but evidently preparing to spawn this season; their lengths were—

(1) 26·7 cm., 10·5 in.	(2) 24·8 cm., 9·8 in.	(3) 23·0 cm., 9·0 in.

The rest were unripe; they varied in length from 23·2 cm. or 9·15 inches down to 7·2 cm. or 2·8 inches.

I placed the ripe males and ripening females in a separate tank, and returned the unripe specimens to the tank they came from.

On March 24th I emptied the tank and examined the unripe specimens again. I found one more ripe male, but this was apparently one that had escaped capture on the previous occasion, as it was injured by the net. It was 21·3 cm. long.

Among the specimens in the small tank, two were left-sided or reversed, that is, having the eyes on the left side instead of on the right. Of the sixty-six specimens in the large tank four were

reversed; one of these sixty-six had a few small patches of pigment on the lower side of the skin, but in no other specimen did any pigment occur on the lower side.

Thus the largest of these specimens known to be two years of age was 26·7 cm. long or 10·5 inches, while the smallest was 7·2 cm. or 2·8 inches. I feel convinced myself that this great difference in size is chiefly due to differences in nutrition, produced by the competition for a limited supply of food among a large number of individuals in a confined space. It proves at least that under certain conditions a flounder may be only 3 inches long when two years old, and it is quite possible that these conditions are sometimes realised in nature. On the other hand, the size of the larger specimens agrees perfectly with the size of those taken at sea which I had estimated to be of about this age.

With respect to sexual or reproductive maturity, the spawning season is not yet passed, and some of the specimens now unripe may be found to be ripe in April or even in May. But I am inclined to think that the majority, if not all, of the specimens found to be unripe in February and March will not spawn this year. I was surprised to find the proportion of ripe specimens so small. It was 16 per cent. in the small tank, 20 per cent. in the large, or 19 per cent. taking the two together. In my last paper I recorded the fact that none of these captive flounders were ripe at one year of age, and inferred that they would breed for the first time when two years old. It now appears that only a small proportion breed at that age, the majority not attaining to sexual maturity in the second spawning season after that in which they were hatched. It seems probable, therefore, that the greater number of young flounders breed for the first time when three years old, while a small proportion begin to breed at two years. If this were the case normally in flounders and other flat-fishes, not only under artificial but under natural conditions, then in this respect the life-history of the flat-fish would resemble that of the salmon, which has been so long and so attentively studied. For, according to the account given by Day in his British Fishes, it has been conclusively proved that out of the salmon fry hatched in a given spring, which become parrs in the following summer, a certain small proportion become smolts in the following spring when one year old, and descend to the sea, while the larger number remain in the rivers as parrs until they are two years old, and then migrate as smolts. Now a smolt which descends in spring returns as a grilse the following autumn and spawns. Therefore a proportion of salmon breed for the first time two years after the autumn in which they themselves were spawned, while the majority do not become sexually mature until the third autumn.

Of course it may be objected that it is unsafe to draw inferences from what takes place under artificial conditions; that fish kept in captivity in tanks may grow at a different rate and breed at different ages from those in their natural state. But the degree to which such differences occur may be ascertained with sufficient certainty by comparing observations made on specimens taken at sea with those made on captive specimens. In my last paper I showed that specimens living under natural conditions are taken at the spawning season, which must be one year old, and yet which are considerably smaller than the smallest ripe specimen recorded. Thus there is here some evidence that the development of the reproductive organs is not greatly modified by confinement.

Dr. Fulton's investigation of the question of immature fish was of a statistical character, and his criterion of immaturity for each species was a criterion of length. He ascertained the length of the smallest ripe fish among a very large number examined and measured, and he regarded all specimens smaller than this as sexually immature, all larger specimens as mature. Mr. Holt in the course of his observations on the west coast of Ireland introduced a new and important consideration, namely, the distinction of the sexes. Dr. Fulton spoke merely of a ripe specimen without reference to the question whether it was male or female, but it had long been known, *e.g.* in the case of the salmon, that a male fish may be sexually ripe when very small indeed, while the smallest ripe female is a great deal larger. Mr. Holt, therefore, records the sex as well as the size of ripe specimens, and finds the smallest ripe female to be considerably larger than the smallest ripe male. The importance of this distinction had been also present to my own mind long before Mr. Holt's results were published. In fact, in my previous paper, which appeared in November, 1891, I have in all cases given the sex of the smallest ripe specimen observed, and in the case of the dab have given the length of the smallest ripe specimen of each sex. My knowledge of Mr. Holt's observations is derived from a proof copy of his reports in the Report of the Council of the Royal Dublin Society for 1891.

In the statistical inquiries of both Holt and Fulton, it is tacitly assumed that the sexual maturity of a fish of a given species depends only on its size. The smallest ripe specimen is found, and it is assumed that all specimens above this size are to be considered as mature. The method of these inquiries naturally involved such an assumption, for while the minimum size of ripe or ripening specimens was ascertained, no attempt was made in them to ascertain the maximum size of immature specimens. In fact, when a specimen caught at sea is not ripe or ripening, we have at present no

criterion by which to find out whether it has spawned before or not; it may be sexually immature, or it may have spawned previously, its sexual organs being merely in an inactive state at that particular time of the year.

Now it was, *à priori*, improbable that the sexual maturity of a fish should depend simply on its size. This could only be the case if every specimen grew to exactly the same size in the same time, if there were no individual variation in the rate of growth. That such a variation exists is obvious from the examination of fishes taken at sea, and my observations on flounders, &c., in captivity, have shown how great the variation may be. Thus, when Fulton finds the smallest ripe flounder to be 7 inches long, it by no means follows that all specimens larger than this have begun to breed. I have given above the lengths of the twelve of my captive specimens which were found to be ripe males in February and March this year. The smallest of them is 6·4 inches long, the largest 9·2 inches. Therefore even a male flounder may be more than 9 inches long before it begins to breed—before it spawns for the first time. Eight out of the twelve ripe males are over 8 inches long. If these had been taken at sea last November, they would have been over 7 inches long, and would, according to Fulton's method, have been classed as mature, while, as a matter of fact, they had not begun to breed, had never yet produced milt. Similarly, with the females there are only four ripe among my captive specimens, and their lengths are from 8·4 inches to 10·5 inches, so that a female flounder may be more than 10 inches long before it breeds for the first time.

The results thus obtained for the flounder probably apply more or less exactly to other kinds of flat-fishes. Hence we may conclude that, when the smallest size of the mature female in a given species has been ascertained, many females do not reach maturity until they are somewhat larger than this. Therefore, in order to exclude all immature individuals, a limit of size must be taken which is above the minimum size of mature females.

Pleuronectes limanda, the Dab.

In the autumn of last year I collected from Cawsand Bay, and other parts of Plymouth Sound, a number of small dabs which I judged to be derived from the spawning of the spring of the same year.

The dates of collection and lengths of these were as follows:

1891	Sept. 29	...	4 specimens	...	4·2—5·3 cm.
	Oct. 1	...	3 „	...	4·0—4·5 „
	„ 1	...	5 „	...	4·3—6·0 „
	„ 2	...	2 „	...	4·2—4·5 „
	„ 6	...	4 „	...	4·0—6·0 „
	„ 10	...	17 „	...	4·0—6·5 „
	„ 12	...	13 „	...	4·0—5·0 „
		Total	48 „		

These were all placed in one table-tank measuring 5 feet by 2½ feet in area, and 1 foot 6 inches in depth. On March 21st, 1882, I measured these fish, or as many of them as I could catch, and found their lengths to vary from 5·0 to 12·2 cm. There were 37 of them : some of course had died. They had been fed with chopped marine worms.

The separate measurements were—

5·0 cm.	...	7·1 cm.	...	9·1 cm.
5·6 „	...	7·5 „	...	9·1 „
5·7 „	...	7·8 „	...	9·2 „
6·0 „	...	7·8 „	...	9·2 „
6·1 „	...	7·8 „	...	9·4 „
6·6 „	...	8·7 „	...	9·8 „
6·6 „	...	8·7 „	...	9·9 „
6·9 „	...	8·8 „	...	10·1 „
7·0 „	...	8·8 „	...	10·2 „
7·0 „	...	8·8 „	...	11·4 „
7·0 „	...	8·9 „	...	11·6 „
7·0 „	...	8·9 „	...	12·2 „
7·0 „	...		...	

In my paper in the preceding number of this Journal, I recorded the fact, that some specimens of the dabs, 4·7 and 5·0 cm. long, were taken in April and May, and stated that these must be a year old, because they could not reach that length if hatched in the same year. I also estimated the maximum length of specimens one year old at 13·5 cm. These conclusions were founded entirely on specimens taken at sea ; the growth of the above-recorded specimens in captivity fully comfirms my previous conclusions. None of the captive specimens showed any signs of sexual maturity, an indication that the dab does not any more than other flat-fishes begin to breed before it is two years old.

Solea vulgaris, the Sole.

I have not yet obtained young soles less than 1 year old at Plymouth, either in shallow or in deep water. Last summer I specially sought for them in deep water, but obtained none. There is some

evidence now that during the summer after they are hatched they remain in shallow water.

Dr. Fulton states that eleven young soles, $2\frac{3}{4}$ to 6 inches long, were taken in June in the Solway Firth, and that six soles, 5 to 7 inches in length, were taken in one morning's fishing on the Lancashire coast; but these are only soles about one year old, such as I stated in my previous paper to be taken in Plymouth Sound. But Mr. H. C. Sorby of Broomfield, Sheffield, has informed me that, in August 1890, he took several soles only about 2 inches long, in Bawdsey Haven in Suffolk. He sent me one specimen of these, and I found there was no doubt about its being of the species *S. vulgaris*. This specimen was 5 cm., or 2 inches long, and having been captured in August must have been about 4 months old.

Zeugopterus punctatus, Müller's Topknot.

On July 9th, 1891, I took four specimens of this species in an otter trawl at a depth of 25 fathoms between the Eddystone and the Rame Head. These specimens measured 6·2, 6·5, 8·2, 9·5 cm. (2·4, 2·6, 3·2, 3·7 inches) respectively. On March 21st, 1892, our fisherman took a specimen 8·4 cm. long 6 miles from the breakwater. To my surprise this small specimen was a perfectly ripe female yielding ripe transparent ova on the slightest pressure. The ova were ·9 mm in diameter and contained a single oil-globule ·15 mm. in diameter. The ova were evidently pelagic. Mr. George Brook has described the eggs of the other species *Z. unimaculatus* (*Ichthyological Notes*, Fourth Report of the Fishery Board for Scotland), and states that they were ·96 mm. diameter in the preserved condition and had a single oil-globule. Brook obtained the eggs from a single ripe female 5 inches in length.

Z. punctatus reaches a maximum length of 7 or 8 inches, about 18 to 20 cm. Those taken in July, 1891, may have been only one year and three or four months old, the ripe specimen being two years, but small for its age.

Scomber scobrus, the Mackerel.

Date.	Locality.	No.	Length.		Weight.		Age.
			Centimetres.	Inches.	Grammes.	Ounces.	
1891 Sept. 30	East side of Plymouth Sound on a whiffing line	1	13·8	5·4	—	—	1 year and 2 months.
Oct. 5	Outside Sound, whiffing lines	4	18, 22·6, 21·9, 25·6	7·1, 8·9, 8·6, 10·1	—	—	1 year and 3 or 4 months.

Date.	Locality.	No.	Length.		Weight.		Age.
			Centimetres.	Inches.	Grammes.	Ounces.	
1891 Nov. 3	Anchovy nets, 1 mile outside Mewstone	5	15·9 to 19·5	6·3 to 7·7	24·0 to 48·9	·8 to 1·7	1 year and 4 months.
Nov. 4	Anchovy nets, off Rame Head	6	16·7 to 20·7	6·6 to 8·2	—	—	"
Nov. 5	Anchovy nets, off Bigbury Bay	33	15·1 to 21·0	5·9 to 8·3	—	—	"
Nov. 16	Anchovy nets, south of the Eddystone	1	19·8	7·8	—	—	"
Nov. 23	Anchovy nets, off Rame Head	4	17·1 to 18·5	6·7 to 7·3	—	—	"
June 10	8 miles outside Eddystone, whiffing	7	22·2 to 23·5, one 26·3	8·7 to 9·3, 10·3	85 to 106·3, 134·5	3 to 3¾, 4¾	1 year. 2 years.
June 23	Mackerel nets, 20 to 30 miles south of Eddystone	5	29·5 to 32·8,	11·6 to 12·9,	163 to 255·1,	7¼ to 9,	2 years.
		1	42·5	16·7	524·4	18½	3 years.
May 27	Off Looe Island	2	30·5, 31·3	12, 12½	205·5 to 230·3	7¼, 8⅛	2 years.
May 27	80 miles south-west of Penzance	2	43·2, 44·5	17, 17½	673·3 to 683·9	23⅝, 24⅛	3 or 4 years.

The spawning period of the mackerel in the vicinity of Plymouth lasts from the middle of May to the end of July, these being its extreme limits. As there is no difficulty in obtaining any number of mackerel during the spawning time, the fish being taken for the market in large numbers in the ripe condition, the evidence available for the determination of the period is abundant. It would be expected that the age of young mackerel could easily be reckoned from such a short and definite spawning season. But I have not found it very easy up to the present time. More abundant data will require to be collected before the question can be satisfactorily answered. In the meantime the few observations in the above table are sufficiently interesting to be recorded, and from them a probable rate of growth can be deduced which may be tested by future observations.

The specimens of the entry for June 23rd in the table were selected by myself on board a mackerel boat. The boat sailed from Plymouth on June 20th, but the nets were not shot that night because there was not wind enough to enable us to get as far as was necessary. During the whole of the next day we were sailing under a light breeze catching mackerel by hook on whiffing lines. We took 150 in this manner, the bait being a slice from the silvery belly or tail of a mackerel already caught. Some of these mackerel were rather small, but the majority were large, and the great

majority were ripe males ; there was not a single ripe female among them, but a few unripe. It may be concluded from this that the males continue feeding when ripe, but the females do not. In the evening we shot the drift-nets, and, on hauling them next morning, got about 150 mackerel, among which were many ripe and many spent. The males were more numerous than the females in this lot also. Of the seven I took for examination six were selected as the smallest of the catch, and the other as a specimen of the larger sort. The condition and dimensions of these specimens were—

Small female, ovaries undeveloped . .	27·4 cm.	... 5¾ oz.
Small ripe female	29·5 „	... 7¼ „
Small ripe male	30·3 „	... 7¾ „
Nearly ripe female	31·0 „	... 8½ „
Small ripe male	31·3 „	... 8¼ „
„ „	32·8 „	... 9 „
Large ripe male	42·5 „	... 1 lb. 2½ oz.

Thus the smallest ripe female taken on this occasion was 29·5 cm. long (11·6 inches) and 7¼ oz. in weight. The female of 5¾ oz. was not shotten and apparently would not have spawned that season, the ovaries being quite undeveloped. The first question to be considered is, assuming about 11 inches to be the length of the smallest mature female, whether this size is usually reached in one year. We have no reason at present to suppose that the mackerel reaches maturity more rapidly than the herring, and I have, therefore, estimated the age of these mackerel, 29·5 cm. to 32·8 cm. in length, at two years. On June 10th, during the spawning period, six specimens were taken of 22·2 to 23·5 cm. in length, and whose weight did not exceed 3¾ oz. These must have been one year old at least ; they showed no signs of sexual maturity, and I have provisionally estimated their age at one year only. Then we have the specimens taken in the anchovy nets in November. I was at first inclined to conclude that these came from the spawning of the previous June or July. But this would make the growth extraordinarily rapid. Mr. Dunn, of Mevagissey, has seen young mackerel of this size in November, and it is his opinion that they are only five months old. The account of the growth given by Day, on Dunn's authority, is that the young are plentiful in the bays in August and September, when they are about 3 inches long, reaching 6 or 7 inches in November ; then they leave for the deep sea and reappear the following June, when they are 8 or 9 inches long. According to this reasoning they would increase 3 or 4 inches in length in the two months October and November, and only 2 inches in the seven months between November and June. This is manifestly improbable, and there are various considerations to support the con-

clusion that these young mackerel of November are really more than a year old, and are derived from the spawning not of the immediately preceding summer but of the previous year. I have shown that the scad (*Caranx trachurus*), which I believe spawns about the same time as the mackerel, is only 2·5 to 3·5 cm. long in September (see my previous paper). The herring is only 8 to 9 cm. long in November when spawned in April or May: the adult mackerel is about six inches longer than the adult herring, and therefore there is no reason to believe that it grows to twice the length in less time.

But the question arises, if these mackerel 16 to 21 cm. are sixteen months old, how can others taken in June and 22 to 23 cm. long be only a year old? The answer to which is, I think, that there is considerable individual variation in size. It it clear that the single specimen, taken at the end of September and measuring 13·8 cm., could not have reached that length in two or three months, and it must have been an unusually small specimen at fourteen months old.

I hope to test and confirm these conclusions this summer by following the growth of the mackerel fry from the hatching time onwards. Hitherto, mackerel fry from a few weeks upwards have not been taken, but by the use of a large and suitable net we may succeed in capturing them.

In the early summer the smaller mackerel, those I conclude to be two years old, are found near the coast, while the larger fish are caught out in the open sea. Thus in May last year Plymouth boats were catching mackerel of 12 or 13 inches in length, and about ½ lb. in weight, off Looe Island on the Cornish coast, while the large Lowestoft boats were bringing in huge mackerel up to more than 1½ lbs. in weight from off Ushant and eighty miles south-west of Penzance.

Clupea harengus, the Herring.

I have not had many opportunities of studying the growth of the herring, but have thought it would be useful to give an inclusive summary of the evidence which has been recorded by others on the subject. The question has been carefully and successfully investigated by H. A. Meyer, in the Baltic. There is a paper by this observer in the *Jahresbericht* of the *Commission zur Untersuchung der deutschen Meere*, for 1874–75–76, published in 1878. The paper is entitled *Observations on the Growth of the Herring in the Western Part of the Baltic.* Before Meyer's work various contradictory opinions had been expressed concerning the growth of the herring. For instance, the English Royal Commission of 1862, whose report was published in 1863 (*Commission on the Operation of the*

Acts relating to Trawling for Herring on the Coasts of Scotland), say that there is reason in Messrs. Yarrell and Mitchell's supposition that herring attain to full size and maturity in eighteen months, but there is no good evidence against the supposition that it reaches its spawning condition in one year. The Commissioners argue that the egg of the herring is hatched in two or three weeks, and that the young attain 3 inches in length in six or seven weeks after hatching, and that in nine months more they would reach 10 or 11 inches in length. In any case eighteen months is to be regarded as the maximum time required by the herring to reach maturity.

Axel Boeck, on the other hand, the Norwegian naturalist, concluded that mature herring were not less than three or more than four years old.

Meyer states that the spawning of spring herring in the Schlei begins in March, but takes place principally in April and May. At the end of May, 1874, he found in the Great Belt near Schleswig many larvæ 2·5 to 2·9 cm. long, on the 10th June 3·3 cm., and on 23rd June 4·3 cm. long. Likewise on 10th June, 1876, he captured larvæ up to 3·8 cm. long, but the majority were only 2·5 to 2·8 cm. If the longest of these came from eggs shed in March they could not be more than three months old, which would give an increase of 1·3 cm. per month. But the majority 2·5 to 2·3 cm. long observed on the 10th June could not be more than six weeks old, which gives an increase of 1·7 to 1·8 cm. for the month.

After about two months of age the herring changes from a transparent elongated larva without scales, and very different in appearance to the adult herring, to the permanent form of the adult. The metamorphosed young are much deeper and thicker in proportion to their length than the younger larvæ. The change of form and acquisition of the silvery livery takes place in the Schlei in July, and by the end of that month the greater number of the spring brood have passed the intermediate stage; they are then 4·5 to 5·5 cm. long. This process of change and the growth during it were watched in specimens kept in captivity in a floating box, the specimens grew from 2·5 to 2·8 cm. on the 11th June to 4·5 to 4·6 cm. on 1st August. At this length they were fully scaled.

In July and August larger young herrings of 7 to 9 cm. long (2·5 to 3·7 inches) are found mixed with the smaller, and evidently come from an earlier spawning. It is certain that the young from the spring spawning, mostly 6·0 to 7·0 cm. in length, leave the Schlei for the Baltic at the end of August and beginning of September. From this time on these young fish show themselves in numbers in all the bays of the Western Baltic, but mixed with another generation of somewhat larger fish, from which they are

separated by no evident limit. Meyer, therefore, measured the growth by taking the lengths of the smallest fish in each catch. Thus the growth of the smallest fish is shown by the following figures:

14th November, 1876 . . .	8·4 cm.	...	3·3 in.
End of November, 1876 . . .	9·0 „	...	3·5 „
End of December, 1876 . . .	10·0 „	...	3·9 „
End of January, 1877 . . .	11·0 „	...	4·3 „
End of February, 1877 . . .	11·4 „	...	4·5 „
End of March, 1877 . . .	13·5 „	...	4·9 „
End of April, 1877	13·8 „	...	5·4 „

This gives an increase of 1·0 cm. per month, but of course, since the variation in size of fishes of the same age is considerable, the mean growth of the young from the spring spawning was somewhat greater. Two rearing experiments made by Meyer for comparison gave a mean result of 1·07 and 1·1 cm. per month respectively; the experiments lasted four and a half and three months respectively.

Concerning the autumn herring, which spawns in the open sea in September and October, Meyer has no very conclusive observations, but the evidence he has indicates that the growth of these is equal to or rather greater in one year than that of the spring herring, the adults being somewhat larger than in the case of the latter. He points out that some herring spawn later than October, even as late as December, so that it is impossible to separate the broods with certainty. He also remarks that the spring herring, between six months and a year old, are not definitely separated in size from the smallest autumn herring of the preceding autumn; and as he took the smallest specimens only for his measurements, we must conclude that the average size of spring herrings at one year old is greater than 5·4 inches; we may, perhaps, put the average size at 6 to 6½ inches, and the maximum at 7.

Meyer proceeds to discuss the amount of growth in the second year, and the age at which puberty is attained in the herring. In his collection, the smallest ripe herrings were 20 cm. long (7·9 inches) while those of 21 to 22 cm., were not rare. Ljungmann states that some herrings off the coast of Sweden are ripe at 17·5 or even 16 cm. length. Meyer argues that, taking 20 cm. as the limit, the year-old fish have only 6 or 7 cm. to add to their length in order to reach it. But he regards it as impossible that the young of the spring-spawning herring should become autumn-spawning herring or *vice versâ*, and since the majority of the herrings which spawn for the first time are more than 20 cm. long, he believes they spawn first at two years old. Meyer does not mention the consideration that an increase of half the total length may, and generally does

mean a doubling of the weight; unfortunately the weight of the fish does not enter into his calculations, but I have no doubt he is perfectly right in his conclusion.

In another paper published separately in octavo in 1878, under the title "Biological Observations made in the Artificial Rearing of Herring of the Western Baltic," Meyer records the increase in size of some larval herrings which were hatched in captivity and kept alive till they were five months old. Some increase in length took place in the first two days, when the largest larvæ measured 9·2 to 9·3 mm. After the eleventh day the number of the larvæ began to be diminished rapidly by death, and the growth was retarded. On the forty-seventh day after fertilization, the young fish measured only 1·2 cm., while according to the observations of the free specimens in the Schlei the length should have been 1·7 cm. The water was now supplied unfiltered and abounding in Copepoda and other small pelagic animals, whereupon the young fish began to grow with very great rapidity, and at the end of five months were as large as their free-living brethren in the Schlei. The lengths observed in the free and the captive specimens were as follows:

Age from fertilization of the eggs.	Length of fry living free in the Schlei.	Length of herrings reared in captivity from Schlei eggs.
1 month	1·7—1·8 cm.	—
2 months	3·4—3·6 „	1·7—1·9 cm.
3 „	4·5—5·0 „	3·0—3·5 „
4 „	5·5—6·1 „	4·8—5·4 „
5 „	6·5—7·2 „	6·5—7·0 „

Thus it will be seen that the young fish in captivity, when they obtained suitable food in abundance, made up for lost time, and at the end of five months were as large as the fish living under natural conditions. From the remarkable rapidity with which these young herrings, after being stunted for a time by want of nourishment, caught up in growth with the free-living fish of the same age, Meyer draws the conclusion that the rate of growth in the herring depends largely on the quantity of food available, and as the latter must be greater in summer than in winter, the rate of growth of the fish must vary at different seasons of the year and in different years, so that only an average rate of growth can be determined.

At Plymouth I have only once seen a number of half-grown herring captured. This was on May 16th, 1889, when I watched a ground-seine being hauled on the south shore of the Cattewater. Some hundreds of herring were brought on shore, and I secured a sample of twenty-four, which measured 11 to 14 cm. (4·3 to 5·5 inches) in length. Now the spawning of herring at Plymouth takes place principally in Bigbury Bay in January and February. I

have observed the evidence of this in ripe and spent herrings brought to market almost every year, but paid particular attention to it in 1888 and 1889. In 1888 I found the spawning continued to the middle of March, and on April 9th, 1891, I examined six ripe herring taken eight miles off Dodman Point in Cornwall, and sent to the Laboratory by Mr. Dunn. In these last specimens the ovaries were burst and the eggs dead in the body-cavity. Mr. Dunn thought that the oviducts were obstructed, and that the eggs had died during the life of the fish, but the condition observed might have been merely due to rough handling at capture. In any case this is an indication that some herrings are spawning on the south-west coast in April, and others may be spawning in May. On the other hand, I have met with no indication whatever that there are any herrings spawning on our south-west coast in autumn. I can only conclude that the herrings above mentioned taken in May were about one year old, though the smallest, 11 cm. long, are smaller than the smallest found by Meyer to be one year old.

In September and October 1890, Professor Weldon measured a number of herring brought to the Laboratory, and taken in seines in the Cattewater and Hamoaze. The total lengths were—

From Cattewater in September, twenty-three specimens measured 17·5 to 21·8 cm. (6·9 to 8·6 inches).

From Hamoaze on October 10th, eleven specimens measured 19·4 to 27·7 cm. (7·6 to 10·9 inches).

From Hamoaze October 14th, thirty-two specimens measured 12·8 to 21·8 cm. (5·0 to 8·6 inches).

There is here a great range in size; it is possible that the smallest, those 5 inches long, were only nine months old, having been hatched in the preceding January, and that the largest, about 26 or 27 cm. long, were in their third year. But I think it is almost certain that the majority, ranging from 19 to 23 cm. in length, were one and three quarter years old, and would complete their two years in the following spawning season, January to March.

These herrings taken in Hamoaze and Cattewater are locally known as habour herring; but adult herrings of a considerable range in size occur in great abundance in Plymouth Sound every autumn and winter, though they always leave the Sound for the open coast before spawning. I see no reason at present to suppose that the herring which ascend the estuaries are of a different race from those which remain in the Sound, although perhaps the younger individuals penetrate further into brackish water than the older.

It is of considerable interest to study the records published in the Reports of the Scottish Fishery Board of young herring taken in

the sprat and whitebait fisheries, in relation to the conclusions summarised above as to the rate of growth of herring in the Baltic. These records were collected for an entirely different purpose, namely, to ascertain the destruction of herring fry entailed by the fisheries mentioned, but they afford valuable evidence on the growth and distribution of young herring. The first of the papers to which I refer is a *Report on the Sprat Fishing on the East Coast of Scotland in the winter of* 1883–84, by the late Mr. J. Duncan Matthews, Second Annual Report of the Fishery Board for Scotland. We find from this paper that in December, January, and February samples were taken at random from the fish taken by the sprat boats using "circle nets" in the Firth of Forth. Of 1671 fish examined in December, 12·8 per cent. were herrings $3\frac{1}{4}$ to $5\frac{1}{4}$ inches long, the percentage in the several samples ranging from 1·5 to 76·4. In January and February the percentage of herrings was considerably smaller, and the size a little greater, namely, from $3\frac{1}{2}$ to $5\frac{3}{4}$ inches. Now there is a thoroughly investigated spawning ground about the Isle of May at the mouth of the Firth of Forth, where herrings spawn every year from the end of January to the end of March, or even later. It is obvious that the size of the largest of the young herrings just mentioned agrees exactly with that of the Baltic spring herrings when one year old. But the question arises, are not the smallest, $3\frac{1}{4}$ inches, too small to be derived from the spring spawning in the Firth of Forth? If spawned in March then in December they would be nine months old, and the size of herring at nine months given by Meyer is 3·9 inches. The agreement is, therefore, very close, and we may conclude that the herring measured by Matthews were derived from the spawn shed at the Isle of May in the previous spring. The autumn spawning on the coast of Scotland takes place in August and September, and there is no great fishery at this time in the immediate neighbourhood of the Firth of Forth. Moreover, young herring hatched in August would be less than 3 inches long in December.

A similar examination with similar results was made of the sprat fishing in the Firth of Tay. The samples were taken in every month from November to February, from the fish captured by the fixed bag-net, and the percentage of young herrings in the samples varied from three to eighty. The herrings were between $3\frac{1}{4}$ and $5\frac{1}{2}$ inches in length. But we have no definite indication of spring spawning at the mouth of the Tay. It is possible enough that the young herring taken in the Tay were originally derived from the same spawning beds as those in the Forth, namely, the ground around the Isle of May. However, there is no doubt that herrings spawn in spring at various places along the east coast of Scotland,

as well as at the Isle of May, although except at the latter place observations on the subject are vague and indefinite.

We pass on now to another paper, namely, one by J. C. Ewart and J. Duncan Matthews in the Fourth Report of the Scottish Fishery Board, on the *Nature of Thames and Forth Whitebait.* The whitebait fishing in the Forth is not, from the present point of view, of great importance. The authors inform us that it is carried on in the Forth between Alloa and Kincardine in the winter months, and the fish captured vary very little in kind; 2600 specimens were examined in samples of about 200 each during December, January, and February, and 99½ per cent. of the whole number consisted of sprats, only about half a dozen herrings being found among them.

The results of the examination of Thames whitebait were very different. These results may be conveniently tabulated thus:

Month.	No. examined.	Percentage of herrings.	Length of herrings.
February	1400	7	Some under 2 inches.
March	1200	5	Some nearly 4 inches.
April	800	14	12 per cent. of the herrings under 1½ inches without scales.
May	600	30	40 per cent. of the herrings 2 inches long and completely scaled; 60 per cent. 1½ to 1¾ inches, and only partly scaled.
June	800	87	60 per cent. of the herrings were fully scaled and from 2 to 2¼ inches long; 40 per cent. 1 to 1½ inches, scaleless, or nearly so.
July	600	75	1½ to 2½ inches; 80 per cent. under 2 inches.
August	500	52	2 to 3 inches.

The remainder of the samples in every case consisted of course of young sprats, and with these I shall deal in discussing the growth of that species. The observations on the herring are extremely interesting and instructive, notwithstanding the fact that the observers were not attending to the question of the rate of growth, and have not therefore given as complete an account of the sizes and conditions as that question demands. The authors of the paper merely remark that the young herring would appear to be developed from spawn deposited during the spring months. We see from the above table that Ewart and Matthews place the limit of size between what we may call larval herring (those without scales and without the silvery livery) and the fully-developed herring at 2 inches, and this agrees with Meyer's observation that the fully-developed young fish were 1·8 to 2·2 inches long. The change is completed in the third month of age according to Meyer.

In February and March the number of larval herring was extremely small, the total number of herrings in a catch being 7 and

5 per cent. and only a few of these under 2 inches. The appearance of the fry can scarcely be said to have commenced, only a precocious individual or two having spawned. In April the fry just begin to appear, 14 per cent. herrings are caught, but only 12 per cent. *of these* are scaleless larvæ. These must have been one to two months old. The larger herrings, over 2 inches long, taken at this time we need not consider at present. In May we have 30 per cent. herrings and 60 per cent. of these are larvæ; that is, 18 per cent. of the total catch are larval herrings. In June we find that 34·8 per cent. of the total catch are larval herring. In July, according to the figures given, the number of larval herring is increased to 60 per cent. of the total catch, while in August there are no larval forms at all. I am obliged to conclude that there is a mistake in the figures for July; probably the number of larvæ declines in that month, and it ought to be "80 per cent. of the herrings caught were over two inches" instead of "under." Making this correction we find the larval herrings were 15 per cent. of the total catch.

If we write down the total number of young herrings under 3 inches, the number of scaleless forms, and the number of scaled forms, all as percentages of the total catch, side by side we get—

	Total number.	Larval forms.	Scaled forms.
April . . .	14	1·6	12·4
May . . .	30	18	12
June . . .	87	34·8	42·2
July . . .	75	60 (15)	15 (60)
August . . .	52	0	52

Assuming that the alteration I have made is correct we find that the number of larval herrings reached a maximum in June, and that these were almost entirely absent in April and August. It is not clear that the 12·4 per cent. of scaled herrings in April were not over 3 inches long and derived from some spawning in the previous year. Leaving these aside, therefore, we find the scaled young under 3 inches long reach a maximum in July, and slightly decrease in August. But the latter decrease is doubtless only apparent, many of the larger individuals of this season's brood having changed their locality and being no longer caught in the whitebait nets.

If we had any reliable information concerning a spring spawning of herring at the mouth of the Thames, we could reckon from the time of this spawning the age of the herring fry taken as whitebait. But I have been unable to find anywhere any record of observations on the spawning of herring in this neighbourhood in spring. All that is stated in Holdsworth's work on Deep Sea Fishing and

Fishing Boats, and Day's History of British and Irish Fishes, is that the herring spawns at Ramsgate in October and November. I can, therefore, only assume the correctness of Meyer's conclusions as to the rate of growth, and from the size of the herring fry measured by Ewart and Matthews, calculate the period at which the spawning occurred from which they were derived.

The larval herring occurring in June were about two months old, some more and some less. This shows that the spawning took place most abundantly in April, while the larval forms taken in May and July must have come from spawn deposited in March and May. Thus all the eggs shed in March and April had become scaled young herrings over 2 inches long in July, constituting 60 per cent. of the catch of the stow-nets, while the 15 per cent. larval forms taken with them came from the last eggs of the season deposited in May. In August no larval forms still unmetamorphosed were left, all the young herrings had undergone their transformation from the naked transparent larval condition to the scaled silvery little fish similar to the adult herring except in size.

There must be then a spring spawning of herrings somewhere near the mouth of the Thames, taking place in March, April, and May. The larger young herring taken in March and April are probably derived from the autumn spawning which takes place off Ramsgate in October and November. Now if we take October as the principal month of the autumn spawning, it is just six months from that month to April, the principal month of the spring spawning, which is a confirmation of the conclusions we have drawn as to the occurrence of the latter. It is surprising that no direct observations have ever been made on this spring spawning of herrings at the mouth of the Thames.

Clupea sprattus, the Sprat.

The character of the spawn of the sprat, and the period at which spawning takes place, have been determined in several localities by direct observation, and there are also a certain number of observations on record from which we may draw some conclusions as to the rate of growth of the species.

The paper on *Whitebait*, by Messrs. Ewart and Matthews, so largely used in the previous discussion of the growth of the herring, also supplies valuable observations on young sprats ; 2600 specimens of whitebait procured from the Firth of Forth, between Alloa and Kincardine, in December, January, and February, consisted almost entirely ($99\frac{1}{2}$ per cent.) of young sprats measuring $1\frac{3}{8}$ to $2\frac{3}{4}$ inches in length. The authors themselves point out that in a previous

paper, Matthews had published evidence concerning the spawning season of the sprat which would make these whitebait sprats six to eight months old. These authors do not always bear in mind that the spawning season of the sprat may differ in different places, but Matthews states in the earlier paper (*Sprat-fishing*, Second Report, Scottish Fishery Board), that he received ripe sprats from Stonehaven, Girvan, and the Firth of Forth only in May and June. I myself took the pelagic eggs of the sprat in the lower part of the Firth of Forth in May and June. Thus we have in this case, the maximum growth of the sprat, that of one spawned in June, and measuring $2\frac{3}{4}$ inches in the following December, $2\frac{3}{4}$ inches in six months, and the minimum, that of one spawned in May, and measuring $1\frac{3}{4}$ inches in the following February, $1\frac{3}{4}$ inches in nine months. The authors do not give separate measurements for the separate months of observation. If we take the mean, both of time and size, we have a length of $2\frac{1}{16}$ inches at seven and a half months of age; and the paper itself states that over 70 per cent. of the sprats examined were from 2 to $2\frac{1}{4}$ inches. The herring at seven and a half months, according to Meyer's results, measures about $3\frac{1}{2}$ inches.

The observations on the sprats in the Thames whitebait are mor detailed, though by no means so much so as the present subject requires. I have tabulated them as follows:

Month.	Total.	Percentage of sprats.	Size of sprats.
February	1400	93	2 to 3 inches.
March	1200	95	2 to $2\frac{1}{2}$ inches.
April	800	86	2 inches average.
May	600	70	$2\frac{1}{2}$ inches.
June	800	13	1 to $2\frac{1}{4}$ inches, the smaller without scales.
July	600	25	8 per cent. of the sprats under $1\frac{1}{4}$ inches, without scales.
August	500	48	1 to $1\frac{1}{2}$ inches.

The number of small scaleless sprats gradually increased during the last month, until 90 per cent. of the samples consisted of these.

The young sprat undergoes a metamorphosis from the naked larval form to the silvery scaled form like the herring, and we see that the young larvæ which began to appear in the Thames in June reached 8 per cent. of the total number of sprats in July, and 90 per cent. of "the samples" in August. It seems as if the total catch was meant by the latter expression, but the meaning may be,

as seems more probable, that 90 per cent. of the sprats alone were young larval forms. We may, I think without much error, assume that the larval sprats were about two months old, as in the case of the herring, and it follows that the spawning of the sprats took place chiefly in June, but occurred also in April and May. I do not know at present to what extent the larger fish are separated from the total catch of the stow-nets before the whitebait are sent to market. But at any rate we know of only one spawning season for sprats, which extends over three or four months, and, therefore, the sprats taken in February, measuring 2 to 3 inches, were doubtless spawned between April and June in the previous year. Thus they were seven to ten months old. Again we may reasonably argue that the sprats taken in April and May before the larvæ of the season had begun to appear, were derived from the previous year's spawning, and were, therefore, about one year old, so that the average size of year-old sprats is not much above 2½ inches. Unfortunately, the size of the year-old sprats taken in June and July is not given; those of 2¼ inches, taken in June must have been a year old, but larger ones may have been picked out before the samples of whitebait were taken. It is clear in any case that a great number of sprats do not exceed 2¼ to 2½ inches at the age of one year, but what the maximum growth may be is not determined.

My own observations on young sprats at Plymouth are not numerous; I have only obtained specimens on the following occasions:

November 21st, 1889, thirty-three specimens 5·5 to 6·6 cm. (2·2 to 2·6 inches) taken in shrimp-trawl in Cawsand Bay.

December 4th, 1889, four specimens, 5·7 to 6·2 cm. (2·2 to 2·4 inches) a sample from a large number killed in the Millbay Docks by blasting under water when I was present.

April 3rd, 1891, thirteen specimens, 8·5 to 9·8 cm. (3·3 to 3·8 inches), caught in a bucket from the side of a boat off Rame Head; sample from a much larger number.

At Plymouth the sprat commences to spawn at the end of January, and the floating ova are found in February, March, and April, so that I think the above specimens registered above were a little less and a little more than a year old respectively.

The only evidence at present available as to the size at which sprats become sexually mature is that of Matthews in his paper in the second Report of the Scottish Fishery Board. He states that of the sprats he obtained from the Forth, only one was 6 inches long, and only two or three 5½ inches, all those near maturity measuring 4 to 4½ inches. It appears, therefore, that small as the adult sprat is it does not reach its mature size in one year, that it is 4 inches

long or very nearly so before it begins to spawn, and does not exceed 3 inches when one year old. It is therefore a probable conclusion that, like the herring, the sprat begins to breed when it is two years old.

Pleuronectes microcephalus, the Merry-sole.

Mr. Holt gives 8 inches as the length of the smallest ripe female of this species obtained by him on the west coast of Ireland.

On March 30th, 1892, I measured two ripe females at Plymouth obtained from a trawler, their lengths were 20·8 and 22·8 cm., or 8·2 and 9·0 inches. The minimum size of mature females is about the same, therefore, on the south coast of England as on the west coast of Ireland. In my previous paper I recorded the length of the smallest ripe male, namely 6·4 inches.

Clupea pilchardus, the Pilchard.

In the preceding number of this Journal I discussed very briefly the early growth of the pilchard, while describing some young stages of the fish which I had taken in the tow-net. I have now to record some further evidence concerning the life-history of this species. Last summer small-meshed drift-nets were obtained for the purpose of the anchovy investigation, and when these were shot from time to time during the autumn and winter, besides other fish a considerable number of small pilchards were taken in them. For details as to nets see paper on *Experiments on the Relative Abundance of Anchovies off the South Coast of England* by Mr. Calderwood, in the present number, p. 10. The number and size of the pilchards taken at each shot of these nets in November and December 1891, and January 1892, are shown in the following table.

Date.	Locality.	Number.	Length.		Weight.	
			Centimetres.	Inches.	Grammes.	Ounces.
1891						
Nov. 3	1 mile south of Mewstone	507	13·0 to 16·2	5·1 to 6·4	14·2 to 30·5	·5 to 1·07
		40	18·3 to 22	7·2 to 8·7	59·6 to 84·8	2·09 to 2·9
Nov. 4	Off Rame Head	19	13·0 to 16·5	5·1 to 6·5	—	—
		7	17·8 to 21·6	7·0 to 8·5	—	—
Nov. 5	Bigbury Bay	188	13·0 to 16·2	5·1 to 6·4	—	—
Nov. 6	South of Mewstone	242	13·0 to 16·5	5·1 to 6·5	—	—
		26	20·8 to 24·5	8·2 to 9·6	—	—
Nov. 16	7 miles south of the Eddystone	114	13·0 to 15·5	5·1 to 6·1	—	—
Nov. 17	8 miles south-west of Start Point	49	13·9 to 15·4	5·5 to 6·0	—	—
		9	21·0 to 23·4	8·2 to 9·2	—	—
Nov. 19	10 miles south of Eddystone	8	As usual	—	—	—
		4	”	—	—	—

Date.	Locality.	Number	Length.		Weight.	
			Centimetres.	Inches,	Grammes.	Ounces.
1891						
Nov. 23	3 miles off Rame	1	13 cm.	5·1	—	—
	Head	10	22·1 to 24·1	8·7 to 9·5	—	—
Nov. 24	West of the Eddy-	136	13·0 to 16·6	5·1 to 6·5	—	—
	stone	6	18·4 to 20·2	7·2 to 7·9	—	—
		19	21·5 to 25·2	8·4 to 9·9	—	—
Nov. 27	6 miles off Looe	35	12·7 to 15·0	5·0 to 5·9	—	—
		9	20·9 to 22·8	8·2 to 8·9	—	—
Dec. 15	Whitsand Bay	2	13·9, 14·1	5·5	—	—
Dec. 16	South-east of Mew-	8	13·5 to 14·4	5·3 to 5·6	—	—
	stone	3	22·9 to 23·7	9·0 to 9·3	—	—
Dec. 17	Near Bolt Head	45	13·5 to 15·6	5·3 to 6·1	—	—
		18	Adult	—	—	—
Dec. 22	10 miles south-east of	13	13·8 to 16·2	5·4 to 6·4	—	—
	the Eddystone	3	19·2 to 20·3	7·5 to 8·0	—	—
1892						
Jan. 12	14 miles south-south-east of Plymouth Sound	2	13·5, 13·6	5·3	—	—

As far as I have been able to discover, young pilchards 13 to 16 cm. in length have not been taken in recent years in any considerable numbers on the coast of Devon or Cornwall. There is a factory at Mevagissey where ordinary full-grown pilchards are preserved in oil and tinned in the same manner as French sardines, and Mr. Dunn, who has been for many years connected with this factory, assured me, not only that no such small pilchards had ever been prepared in the factory, but that a deliberate attempt had been made to procure such fish and had not succeeded. A seine of the kind used in the French sardine fishery was obtained from France and several trials made with it, but, instead of half-grown pilchards of the required size, only very young specimens 2 or 3 inches long were captured. Nevertheless it would seem, from the facts here recorded, that small pilchards in all respects similar to the French sardines are to be taken on the English coast.

It will be seen from the table that the young pilchards were most plentiful in November, and scarce in December and January, and that they were taken in considerable numbers in November from the Mewstone to a distance of seven miles south of the Eddystone. If there are any facts or considerations which serve to indicate with more or less probability the age of these young fish, we obtain some light on the question of the rate of growth of the pilchard. In previous papers in this Journal I have shown that the spawning period of the pilchard near Plymouth extends from June to October, but the spawning takes place principally in June, July, August, and September. Therefore the pilchards 13 to 16·5 cm. long in

November must have been either from two to five months old, having been hatched in the summer of the same year, or from fourteen to seventeen months old, having been hatched in the summer of the previous year. It is obvious that the pilchard could not reach a length of 13 cm. in two months, and we have observations on the growth of the young herring, and on the Mediterranean sardine at Marseilles, which show that it could not grow to such a size even in five or six months. Marion's conclusions concerning the sardine at Marseilles are quoted in my paper on the pilchard in the previous number of this Journal; he estimates the length of the year-old fish at 14 cm. I see no reason to suppose that the pilchard at Plymouth grows twice as fast as the sardine at Marseilles. Meyer, after a series of very careful and successful observations, found that the herring in the Baltic at five months old was 6·5 cm. to 7·2 cm. long, and we have no reason to think that the pilchard grows twice as fast as the herring. It is nearly certain, therefore, that the pilchards taken at Plymouth in November and measuring 13 to 16·5 cm. in length, were a little more than a year old, being derived from the spawn of the preceding year. But if this be so, where were the young pilchards derived from the spawn shed in the previous summer of the same year?

I had not seen any very young pilchards, that is specimens less than 13 cm. long, since July last when I took the stages described in the previous number of this Journal. At the end of October I was at Mevagissey and discussed the pilchard question with Mr. Dunn. He told me that young pilchards only 2 to 3 inches long were always on the coast between September and Christmas, and that he knew this because he found them at that period in the whitings' stomachs. He gave me several specimens measuring 5 to 8 cm. in length which he said were taken some years ago in a mackerel seine in September. At Plymouth in November I opened the stomachs of many whiting but found no young pilchards in them. But on opening the stomachs of some mackerel I found the kind of fish for which I was searching. On November 5th I opened twelve mackerel, 10 to 11 inches long, bought on the fish-quay; in one of these were two pilchards 6 and 8·5 cm. long which were sufficiently intact to be identified with certainty; in another was a pilchard 9 cm. long, while in two others were half-digested fish which were probably also young pilchards of similar size. On November 6th I opened thirty-three mackerel, in seven of which there was food in the stomach, in each case consisting of one or two more or less digested fish 5 to 7 cm. long, apparently pilchards. In one of these mackerel there were remnants of several fish in the condition of *poutines nues*, and these were certainly clupeoids and probably pilchards.

It is thus conclusively demonstrated that in November last, when the year-old pilchards were taken in our nets, the mackerel were feeding on younger pilchards 6 to 9 cm. in length (2·3 to 3·5 inches) which were derived from spawn shed the previous summer.

It seems probable that the pilchards which are 13 to 16 cm. long in November would reach the adult condition at a length of 20 or 22 cm. by the following summer, and would then breed for the first time. I have not yet definitely ascertained that pilchards do breed at the size just mentioned. I measured five ripe females in June, 1891, and they were from 23·7 to 24·8 cm. long, weighing from 5 to $5\frac{3}{4}$ oz. But probably if a large number of ripe specimens were measured many would be found to be less than 23 cm. long. I have measured samples of the ordinary adult pilchards taken for the market at various times of the year. For instance, in—

August, 1891, I measured fourteen specimens taken six or seven miles off shore in Whitsand Bay; eleven were females 21 cm. to 25·3 cm. long, in all of which the ovaries were small, and in many apparently recently emptied; the other three were males 21·3 and 21·4 cm. long.

November 3rd, 1891, I measured six specimens from a large catch taken off Plymouth Sound: they were 21 cm. to 22·5 cm. in length, two females, 4 males; the generative organs in all very small.

The largest pilchard I have seen was brought to me in December, 1890, and measured $27\frac{1}{2}$ cm. = 11 inches in length; it weighed $8\frac{1}{2}$ oz., and its generative organs were extremely small and rudimentary, as though it had become sterile from old age.

In my preceding paper on the pilchard in this Journal, and in an article in Nature, January 14, 1892, I have referred to Professor Pouchet's Reports on observations on the sardine made at Concarneau on the coast of Brittany. I propose here to give a more extensive account and criticism of Pouchet's records, comparing them with those I have made at Plymouth, in order to see if they confirm, supplement, or modify the conclusions I have suggested above as to the rate of growth. The records in question date from the year 1887, only a few scattered observations having been made before that time. I will give here a list of the publications in which these records are contained:

(1) *Rapport sur le Fonctionnement du Laboratoire de Concarneau en 1887 et sur la Sardine,* par M. G. Pouchet. Ministère de l'Instruction publique et des Beaux-Arts. Paris, Imprimerie Nationale, 1888.

(2) *Le Régime de la Sardine sur la Côte Océanique de France en* 1887, par M. G. Pouchet. Comptes Rendus, 20 February, 1888.

(3) *Rapport sur le Laboratoire de Concarneau en* 1888 *et sur la Sardine,* Journ. de l'Anat et de la Phys., 1889.

(4) *Sur la Croissance de la Sardine océanique,* Comptes Rendus, 29 July, 1889. Tome cix, No. 3.

(5) *La Question de la Sardine,* Revue Scientifique, 11 Juin, 1887.

(6) *Le Régime de la Sardine,* Revue Scientifique, 24 Août, 1889.

(7) *Rapport sur le Laboratoire de Concarneau en* 1889 *et sur la Sardine,* Journ. de l'Anat. et de la Phys., 1890.

(8) *Nouvelles observations sur la Sardine océanique,* Comptes Rendus, 7 Avril, 1891. Tome cxii.

In the first document in this list (1) we find in the general report the following argument:

Admitting that the *sardine de dérive* (*i. e.* the full-grown sardine, which is in all respects the same as the English pilchard), which is fished at the end of winter, is sometimes almost ready to spawn, it is impossible to admit that the *sardine de rogue,* which is taken during the following six or seven months, is derived from the spawning of these large sardines in the same year. Judging from the data furnished by Coste and others concerning the growth of the salmon and trout, and by H. A. Meyer as to the growth of the herring, we may in all probability attribute to the sardine an increase of 1 centimetre per month. Thus, the ordinary *sardine de rogue,* 10 to 12 centimetres long, would be about one year old.

Annexe E of this same report contains a tabular record of the results of the examination of sardines at Concarneau from May 8th to October 23rd, 1887. In this appendix no information is given concerning the limits of size or the general character of the whole catch for any particular day; each entry consists merely of the dimensions and other particulars of one or a few specimens examined at a certain date. From the 8th to the 26th of May inclusive, seventeen fish were examined; these were from 17·6 to 22·5 cm. in length; with the exception of one, the smallest, these were all adult sardines, and in some of them the generative organs were approaching maturity. The *sardine de rogue* had not yet made its appearance. On May 27th a specimen was 16·0 cm. long. In June four specimens are recorded, 14·8 to 16·8 cm. long, weighing from 25 to 42 grammes. In July fourteen specimens examined; two of these were adult, 18·2 to 20·5 cm. long; the rest were from 12·0 to 17·9 cm. On the 6th and 29th of August two very small specimens are recorded, measuring only 9·8 and about 10·5 cm.; the other nine examined this month were from 12·0 to 15·1 cm. Even the smallest of these, 9·8 cm. long, was probably too large to be derived from the same year's spawning, and represents the spawn shed late the preceding year. In September sixteen specimens

were examined; the lengths, when given, are from 13·5 to 17·0 cm., the weight from 9 grammes to 46 grammes. In October, of eighteen specimens examined two were adult, measuring 19·5 and 19·8 cm., of the rest the lengths are rarely given, but the weights are from 15 to 58 grams.

If we exclude from the above records the fish which I have specified as adult, and which are probably two years old, and also bear in mind that the spawning period of the pilchard extends from the end of May to the beginning of November at Concarneau, doubtless as at Plymouth, I think we may fairly conclude that the French *sardine de rogue,* measuring from 12 to 17 cm. in length, is the product of the previous year's spawning, and is about one year old.

In Appendix D of the same report, where a *résumé* of observations on the year's fishing is given by M. Bovier-Lapierre, the size of the fish being indicated only by weight, it is stated that the year 1887 was remarkable, firstly for the abundance of the fish, secondly for the constant mixture of fish of different sizes, thirdly for the small size of part of the fish.

In the paper (2) published in the Comptes Rendus a fact is mentioned which is not sufficiently indicated in the Report, namely, the appearance in great numbers at the commencement of June of sardines too small for the market, and weighing only three or four grammes. The length of these is unfortunately not stated, but can be calculated at 7 or 8 cm., so that these also were too large to be derived from the same year's spawning, and would seem to indicate merely a late spawning of the previous year.

The article in the Revue Scientifique, No. 5, in the list of Pouchet's papers contains nothing bearing upon the growth of the sardine beyond what I have noticed in the other two papers.

In the Report for 1888 (No. 3 in the list) we have voluminous documents on the sardine. As in the preceding Report we have actual measurements and details of a few sardines examined at short intervals during the season. The drift fishing was continued till May 29th, and was then succeeded by the fishing *à la rogue,* that is with cod-roe bait. The individuals examined at the Laboratory in April and May were nine in number; three of these were adult, 19·0 to 19·5 cm. in length (that is to say, were the *sardines de rogue* of the preceding year, and now nearly two years old). The rest were 10·7 to 14·0 cm. long, evidently the produce of the previous summer's spawning. In May measurements of several adult individuals are given (*sardines de dérive*), but there are also a few *sardines de rogue* measuring about 15·0 cm. The records for the rest of the summer are similar to those of the preceding year, the *sardines de rogue* varying from 14 to 16 or 17 cm. The general

characters of the fishery for the summer season are thus described: the fish appeared first at the south at Sables d'Olonne (May 9th), and then progressively at more northern centres, arriving at Douarnenez on June 10th. Similarly, the fishery terminated first in the south on October 10th, continuing in the north a month later. The dimensions of the fish were remarkably uniform, the diminution in size usually observed about July not having occurred in 1888. On the other hand, a slight increase in the average size, quite sensible and general, was observable from the commencement to the termination of the fishery. A peculiarity of the year was the absence of fish from the 1st to the 20th of July. Pouchet points out that the observations on individual sardines made in the Laboratory prove that the *sardine de rogue* is a young fish which has never spawned, nearly mature ovaries being found only in the *sardine de dérive*. He adds that unfortunately the incessant displacement of the *sardine de rogue*, and its final disappearance in autumn, deprive us of the principal elements necessary to approach the interesting problem of its rate of growth, and of the age of those which visit the French coast in summer. With this opinion I am unable to agree; it seems to me that although we cannot actually observe the increase in size in given individuals, or even a given shoal, yet since we know pretty accurately the extent of the spawning period, we can judge with sufficient certainty from which spawning season fish of a particular size taken at a particular period of the year are derived.

Neither in the Report for 1888 nor in that for 1887 are there any actual observations as to the range of size of the fish caught on particular days throughout the season, but only, as I have already mentioned, measurements of two or three specimens made several times a month. There is not even anything to indicate whether the individual fish selected represented the minimum, maximum, or average size of the fish caught. In this Report for 1888 a substitute is presented for the data to the absence of which I refer, namely, the records obtained by a sardine-curer of the average size of the fish used in each week, expressed by the number of fish required to fill a box of a certain size known in the trade as the *boîte d'un quart*, and measuring $12 \times 10 \times 2$ cm. These records extend over several years, and include several different fishing stations. In these tables the highest figures represent the smallest fish, because of course the smaller the fish the larger the number required to fill a box whose size is fixed. The actual size represented by the figures is not easy to ascertain with any certainty, but some approximation to it may be made by means of relations given by Pouchet.*

* Thus the weight of fish in a box is 123 grammes; this amount of fish when fresh

The character of the fishery, what Pouchet calls the *régime*, varies to a certain degree from year to year; but in the several places named, such as Quiberon, Kernevel, Concarneau, Douarnenez, there is considerable similarity in the same year. The size of the fish taken in different years at the same month varies, but usually the number to the box is ten to fourteen in July, and seven to eight in October. But the fishing begins in June, or the end of May, and the fish taken in these months is usually larger than that taken in July, giving only seven to nine to the box. The smaller fish which usually appears in July is called the *poisson de Juillet.* In some years the diminution in July is not observable, the fish gradually increasing in size from the beginning to the end of the season, and appearing to grow in size on the fishing ground. In other years again, for instance in 1887, extremely small fish, twenty to twenty-six to the box, made their appearance in September and October on the whole coast, with the exception of the Bay of Douarnenez, into which they did not penetrate.

I reproduce here the table of relations between the number of fish to the box and the weight of the single fish, as given by Pouchet, with an additional column showing approximately the corresponding length of the fish.

Number of sardines to the quarter box.		Weight of each sardine.		Corresponding length of sardine.
33—35	...	7·3 grams.	...	10·0 cm.
28—30	...	8·6 „	...	10·5 „
24—25	...	10·2 „	...	11·3 „
20	...	12·5 „	...	11·5 „
18	...	13·8 „	...	12·0 „
16	...	15·6 „	...	12·5 „
15	...	16·6 „	...	12·8 „
14	...	17·2 „	...	13·0 „
13	...	19·2 „	...	13·4 „
12	...	20·8 „	...	13·7 „
11	...	22·7 „	...	14·0 „
10	...	25·0 „	...	14·5 „
9	...	27·7 „	...	15·0 „
8	...	31·2 „	...	15·5 „
7	...	35·7 „	...	16·2 „
6	...	41·6 „	...	17·0 „
3	...	83·3 „	...	21·4 „

With these relations may be compared the actual lengths and

would weigh twice as much, or 250 grammes nearly. Therefore if we divide 250 by the number of fish to a box we get the average weight of a single fresh fish. For instance, 12 to a box means fish each of which weighs 20·8 grammes. Again, Pouchet gives a curve of the relation between the weight and length of the sardine based upon actual observations, and from this we find that a weight of 20·8 grammes correspond to a length of about 13·6 cm., a result which agrees with my own observations.

weights ascertained by myself from the specimens taken at Plymouth on November 3rd, 1891.

14·25 grms.	... 13·0 cm.		30·55 grms.	... 16·2 cm.
17·65 „	... 13·7 „		59·60 „	... 18·6 „
21·80 „	... 14·3 „		55·50 „	... 19·0 „
23·50 „	... 15·0 „		74·70 „	... 19·4 „
30·95 „	... 15·8 „		69·40 „	... 19·7 „
32·70 „	... 16·0 „		84·40 „	... 21·4 „
34·15 „	... 16·1 „		84·85 „	... 21·8 „

It will be seen that the differences between the proportions observed by me, and those taken from Pouchet, are not very great, the lengths in the latter being a little too small in proportion to the weight. However, we may take the lengths of the fish corresponding to the number to a box, as given above, to be approximately correct, and interpreting the annual records in Pouchet's reports by their means, we may try to discover what are the biological facts underlying the industrial statistics.

But before offering my own interpretations and criticisms, I must quote those of Pouchet himself, who devotes a special short appendix in the Report for 1888 (Annexe D) to the subject of the growth and the age of the sardine. Pouchet regards this question, as he regards all others concerning the life history of the sardine, from the most sceptical point of view possible, insisting that no calculation, without the observation regularly followed of the same individuals, can give us exact information concerning the growth of any species of animal, as the growth, whether in weight or length, may describe the most irregular curves. He refers to what he said in the previous Report, for 1887 as to the probability that the *sardine de rogue* is about one year old, that it has never spawned, and that from October onwards it begins to show indications of the development of the genital organs. He then discusses the apparent increase in size of the fish in the same locality, as shown by the industrial records. This gradual increase presents itself more frequently in the Bay of Douarnenez as though the fish which entered the bay remained there and grew; but, on the other hand, sudden changes of size show that the fish even there very often depart and give place to new shoals. Pouchet takes the records of the years in which this gradual increase was most regular, and translating the figures into weight and lengths of individual fish, compares the results with one another, with the following results:

DOUARNENEZ, 1888.

15 to box to 9 to box.
16·6 grms. to 27 grms. = 11 grms.
12·5 cm. to 14·8 cm. = 2·3 cm.

} 15th August to 10th October. 56 days.

BELLE-ISLE, 1888.

15 to box to 8 to box. 16·6 grms. to 30 grms. = 14 grms. 12·5 cm. to 15·0 cm. = 2·5 cm.	10th September to 30th November. 81 days.

LE CROISIC, 1888.

12 to box to 9 to box. 20 grms. to 27 grms. = 7 grms. 14·0 cm. to 14·5 cm. = 0·5 cm.	15th August to 15th October. 61 days.

QUIBERON, 1884.

12 to box to 6 to box. 22 grms. to 40 grms. = 18 grms. 13·0 cm. to 17·7 cm. = 4·7 cm.	15th June to 21st September. 98 days.

KERNEVEL, 1869.

12 to box to 7 to box. 20 grms. to 34 grms. = 14 grms. 14·0 cm. to 16·5 cm. = 2·5 cm.	24th July to 22nd November. 121 days.

These are sufficient to show the irregularity of the results obtained in this way. I have copied the figures as given by Pouchet. Pouchet thinks that the growth of a pelagic species like the pilchard ought to be very uniform, because they inhabit water of uniform temperature, and their microscopic food is always sufficient. He thinks that the inequality of the above results must be due either to the character of the records from which they are derived, or to the fact that the differences of size in the records represent displacements of the fish and not the growth of stationary fish. There is doubtless much reason for this judgement, but I am sorry to be obliged to point out that the calculation of these results offered as samples is marred with serious errors. Thus, the period chosen at Belle Isle for 1888 is 10th September to 30th November, and it is said that the record for the latter day is eight fish to the box, whereas the table for 1888, from which the figures are taken, ends at November 14th, and gives no figures for November 30th, the figure 8 occurring on October 27th.

The figure 12 as the number per box at two places is translated into weight 20 grms., length 14·0 cm.; at another into weight 22 grms., length 13·0 cm., as though the length of the fish decreased as the weight increased. The lengths given as corresponding to the weights do not agree with the graphic on another page of the report.

Pouchet's industrial records occasionally show two features which are worthy of attention, namely, the appearance of smaller fish in July, and the appearance of still smaller specimens in September and October. This '*poisson de Juillet*' is represented by the figures 11 to 13, so that its size is 13·4 to 14·0 cm., and its weight 19·2 to 22·7 grms. Its occurrence is indicated by Pouchet in the

years 1873, 1874, 1875, 1876, and a trace of it in 1878, that is in five years only out of twenty-five of which he gives the "*régime*." In the years in which it occurred the fish caught in June were 15 to 17 cm. long. But in many years, in which the diminution in July is not observable, the fish caught in June are no larger than the *poisson de Juillet*; for instance, in 1877, 1878, 1879, 1883, 1884. Such facts as these, it seems to me, are not surprising when we consider that the pilchard has a spawning period of five or six months, and that its movements are probably not regular. Probably fish 15 or 16 cm. long, caught in June, are fish hatched unusually early in the preceding season, while those of 13 to 14 cm. are produced from a later spawning. In some years the fish are throughout the season of unusually small size, and this may be due to a scarcity of food in the preceding winter. The very small fish occurring in 1887 in September and October were 11·0 to 11·5 cm. long, and probably were derived from eggs shed the preceding May and June, having grown unusually fast.

I quite agree with Pouchet that it is impossible to obtain from the industrial records satisfactory evidence of the actual increase in size of the sardine from the beginning to the end of the fishing season. The data we have to deal with, even when the calculations are arithmetically correct, as Pouchet's are not, are such distant approximations, and it is so evident that in most cases we are not comparing the average sizes of the same shoals, that no great importance can be attached to the difference in size shown between the fish in different months. All that can be said is that usually a difference of 2·5 to 3·5 cm. in length is the result of comparing the sizes of the fish given for July and October.

The subject of the nets used in the French fishery deserves some mention. Unfortunately Professor Pouchet does not give a complete account of them; but he states in one place that the mesh is measured by the length occupied by five knots, that is a length equal to four times the side of one mesh, and I find from the figures he gives that the mesh of the nets used varies from $\frac{4}{10}$ths to $\frac{6}{10}$ths of an inch. I gather that the nets here referred to are drift nets used with the bait or rogue, for it is stated that the fishermen change their nets to suit the varying size of the fish, which they would not need to do if they were using a suitable seine. Thus, some of the nets used in the French fishery have the same mesh as those we have been using at Plymouth. It must be remembered that Professor Pouchet only refers to the fish caught by the fishermen; he denies that there are ever any still smaller fish a few weeks or months old in the waters where the fishery is carried on, but as the nets used could not catch these smaller fish of 3 to 7 or

8 cm. in length the absence of the latter is of course not proved. Seines are also used in the French fishery, but not generally, and their introduction has given rise to a great deal of agitation, the majority of the fishermen with their usual conservatism asserting that the greater efficiency of the seines, which secure very large catches, upsets the regular working of the industrial organisation, and will lead to the extermination of the sardine.

In Pouchet's Report for 1889 we have the *régime* of the *sardine de rogue* for that year exhibited and discussed in the usual manner. The table of the season appears to be taken, like that for 1888, from the trade journal published at Nantes, and gives the average number of the fish per box for every day of the season. In the Report it is pointed out that the constant phenomena evident in this, as in all seasons, are—1st, that the fish is always smaller at the south of the fishing area, namely, towards Sables d'Olonne, than in the north towards Concarneau; 2nd, that the fishing begins first in the south and extends progressively towards the northern stations, and ceases in the same order. Thus, the fishing commenced at Sables on May 3rd at Douarnenez on June 15th, was over at Sables on the 15th September, and on the coast of Finisterre continued till the 15th November.

The peculiar features of the season were the following:—Up to the 15th August the fish continued of the same dimensions, then on the coast of Finisterre very small fish came in, which might be regarded as the *poisson de Juillet*, appearing some weeks later than usual. These fish showed themselves from the south to the north progressively. If we look at the figures for Concarneau we find the size of the fish in July was 8 to 10, that is 14·5 to 15·5 cm. long, 25 to 31 grammes in weight. The small fish were taken only on three or four days in August, and were 26 to 30 to the box, that is about 8·6 grammes in weight, and 10·5 cm. long. Small as these seem to have been, and difficult as it is to judge of their real size by such an unsatisfactory method, it seems to me that they must have been derived from a late spawning of the previous year.

In this same Report Pouchet gives a complete record of his observations on the condition of the generative organs in the adult sardines, the chief result of which is that he found mature eggs only in specimens over 19 cm. in length, and only in April, 1890, and May, 1888.

In my endeavours above to deduce the age of the *sardines de rogue,* whose sizes are recorded by Pouchet, I have assumed that the spawning period at Concarneau is practically the same as at Plymouth. Pouchet's observations show that some pilchards spawn at Concarneau in April; but they give no indication of summer or

autumn spawning. At Plymouth I have evidence that spawning goes on in every month from June to November inclusive; it may be that some pilchards spawn both at Concarneau and at Plymouth also in April and May, or it may be that spawning commences earlier in the Bay of Biscay than further north in the English Channel, or it may be that the individuals found to contain some mature ova by Pouchet, would not have actually spawned till near the end of May. In any case, we have at present no indication that there are two spawning periods, or more than one maximum and minimum of spawning activity in the species.

In the note in the Comptes Rendus of April, 1891, Pouchet merely summarises the results of the observations in his last report, which I have already reviewed. After studying the researches continued for several years at Concarneau, we cannot help being surprised that so much careful and systematic work should have contributed so little to the elucidation of the life-history of the sardine. The reasons for this failure are, it seems to me, of two kinds:—1st, the adoption by Professor Pouchet of preconceived ideas concerning the mode of life of the species, and the relation between this mode of life and the sardine fishery; 2nd, the employment of inadequate and unsuitable methods, and want of experience in the investigation of the history of marine fishes in general. I cannot help thinking that results of greater value would have been obtained if the actual weights and measurements had been ascertained in the Laboratory of large samples of the fish caught, if the *régime* of the fishery had been expressed in scientific rather than industrial terms. It seems also probable that if pelagic collecting had been carried on with sufficient frequency and suitable instruments in the summer off the French coast, the eggs and alevins of the pilchard would have been obtained in abundance in all stages.

However this may be, it is very desirable that the number and character of young pilchards occurring in the neighbourhood of Plymouth throughout the year should be ascertained, and for this purpose I have suggested that our small-meshed nets should be shot three or four times every month during the present season. It would be still better if we had a fleet of nets of various different meshes, so as to take fish of various sizes.

The position and extent of the region where the French sardine fishery and preserving industry are carried on are indicated in the map appended to this paper, in which the situation of all the localities mentioned can be seen at a glance.

Engraulis encrasicholus, the Anchovy.

The Dutch ichthyologist, C. K. Hoffmann,* when investigating the anchovy in the Zuyder Zee, captured a number of the young of this species at short intervals in August, September, and October. Their numbers and sizes were as follows :

Date.	Number.	Length.	Date.	Number.	Length.
Aug. 4	10	4·2—5·2 cm.	Sept. 4	6	7·0—10·0 cm.
„ 8	9	3·2—5·5 „	„ 5	5	5·0—7·0 „
„ 10	10	4·5—6·5 „	„ 8	8	5·5—7·5 „
„ 12	9	4·5—6·5 „	„ 9	9	6·0—7·5 „
„ 14	9	3·8—7·2 „	„ 10	7	6·0—8·5 „
„ 19	6	5·5—7·0 „	„ 22	5	8·0—9·5 „
„ 20	8	6·0—7·5 „	„ 24	6	7·0—9·5 „
„ 22	7	6·0—8·0 „	„ 26	6	9·0—9·5 „
„ 24	10	3·5—6·0 „	Oct. 9	8	7·0—9·0 „
„ 25	7	5·5—7·0 „	„ 12	5	9·5—10·5 „
„ 26	6	4·5—6·5 „	„ 14	6	8·5—11·0 „
„ 27	6	5·5—8·0 „	„ 17	8	8·5—11·5 „
„ 28	6	6·2—8·0 „	End	6	10·0—12·0 „

Hoffmann proceeds to state that the average length of the sexually mature spawning anchovy is 15 cm., but ripe specimens of only 13·0 to 13·5 cm. are not altogether rare. The conclusion which he draws from his observations, and which he emphasises by means of italics, is the following :—" The anchovy comes in shoals into the Zuyder Zee in order to spawn ; those which are not captured depart after spawning, except a few which remain behind. The young brood remain during the first months of their life in the Zuyder Zee ; they grow very fast, and at the end of October have already reached a length of 12 cm. ; then, and not till then, the young depart."

At the time when Hoffmann formed this conclusion the larval stage of the anchovy was unknown, and the fertilised eggs had not been seen. But Hoffmann had himself observed that the anchovies in the Zuyder Zee were sexually ripe in the latter half of June and in July. In the last week of July all the anchovies he obtained had just shed their spawn. He argues that temperature has a very great influence, not merely on the time of development of the eggs of fishes, but on their rate of growth, and that the anchovy grows very fast on account of the high summer temperature of the water of the Zuyder Zee. He refers to Meyer's result concerning the spring herring in the Baltic, namely, that the young hatched in April and May reach a length of 3·5 to 4·2 cm. in two or three months.

* *Bijdrage tot de kennis der levenswjze en der voortplanting van de ansjovis,* Verslag van den Staat der Nederlandsche Zeevisscherijen over 1885, Bijlage ii.

Ehrenbaum,* in a paper just published, has criticised Hoffmann's observations and conclusions, and shows that it is much more probable that the young anchovies examined and measured by the latter were in their second year. In this opinion I entirely agree with Ehrenbaum. We know now, from the researches of Wenckebach and others, carried out subsequently to Hoffmann's, that the anchovy spawns in the Zuyder Zee only in June and July, and we know that the herring does not commence its metamorphosis until it is two months old, when it is 3·4 to 3·6 cm. long. Without very clear evidence to the contrary, which Hoffmann did not obtain, we must suppose that the anchovy would commence its metamorphosis at the same age and a much smaller size, seeing that the adult anchovy is only about half the size of the herring. The anchovy larvæ of the year in the Zuyder Zee at the beginning of August would be only two to eight weeks old, and therefore still in the larval state, without scales, the oldest having a length of about 2·0 cm. Therefore, even the smallest of the specimens recorded by Hoffmann must have been a year old. According to Hoffmann's view the anchovy would reach in about four months the same length as the herring takes ten months to attain to, although the herring is so much the larger fish. Hoffmann's observations prove in fact conclusively the very opposite of the proposition he maintains, namely, that just after the spawning time of the anchovy, year-old specimens are obtained, which are incapable of reproduction, and even at the end of the following October these anchovies are smaller than the smallest mature individuals. Hence it is clear that the anchovy breeds for the first time like the herring and sprat and the flat-fishes, when it is two years old.

In 1890 a Report on the Zuyder Zee Fishery by Dr. P. P. C. Hoek was published by the Dutch *Collegie voor de Zeevisscherijen,* and a chapter of this Report is devoted to the fishes of the Zuyder Zee. This chapter, with slight modifications, was also published in English in the *Tijdschrift der Nederlandsche Dierkundige Vereeniging* for 1890. Somewhat to my surprise I find that Dr. Hoek accepts Hoffmann's conclusions concerning the growth of the anchovy. Hoek's observations were as follows :—On July 6th he took an anchovy larva of about 1·5 cm. in length. He does not say how the larva was identified, merely referring to its characteristic shape. The larva is evidently still without scales, at the stage when the permanent dorsal, caudal, and ventral (or anal) fins have recently been defined, and the primordial fin-membrane has disappeared. It is difficult to judge from the figure whether the permanent fin-rays have appeared,

* *Die Sardelle* (*Engraulis encrasicholus,* L.), Mittheilungen der Sektion für Küsten und Hochseefischerei der deutschen Fischerei Vereins, Jahrgang 1892.

or the temporary finer rays still remain. The figure shows the specimen in a somewhat shrunken condition. The stage of this specimen is somewhat earlier than that of the pilchard larva figured by me in Plate X, vol. ii, Part 2 of this Journal. This anchovy larva must have been not more than one month old, having been hatched in June. On September 19th Hoek obtained some small anchovies measuring 6·2 to 8·5 cm., and estimates their age at two and a half to three months, an age at which the herring measures 4·5 to 5·0 cm.

Hoffmann has also described specimens believed by him to be larvæ of the anchovy.* His identification was based on the fact that the number of the vertebræ was forty-eight. Günther gives the vertebræ in the sprat as forty-seven to forty-nine. Möbius and Heincke forty-six to fifty; the latter authors give the number in the anchovy as forty-six to forty-eight. Matthews found the number in the sprat to be forty-eight. But Hoffmann says he found always forty-nine to fifty vertebræ in the sprat in the Zuyder Zee, and forty-eight in the anchovy. The clupeoid larvæ he took were captured on July 27th to 31st, and varied in length from 16 to 30 mm. The smaller of these might easily have been anchovies hatched in June; that the largest were anchovies in much more doubtful; but even if they were, it would by no means prove that young anchovies hatched in June could reach a length of 8·0 cm. in August.

Reference has previously been made in this Journal† to Hoffmann's theory concerning the relation between the summer temperature of the air in the region of the Zuyder Zee and the variations in the annual catch of anchovies from that body of water. The theory is that an unusually warm summer in one year is followed by an unusually large catch of anchovies in the following year. The explanation of the supposed sequence is that the warm summer means a very abundant production of eggs and young larvæ of the anchovy; the high temperature ensures an abundance of food for the young fish, and also favours their healthy development and growth. The young thus survive in unusual abundance, to depart for the open sea in autumn and return in the following summer, and give rise to a successful fishery. It may be suspected that the theory itself owed its origin partly to Hoffmann's mistaken belief that the anchovy reached its adult size and condition in one year. That belief having been proved to be unfounded, some other explanation of the connection between summer temperature and fishery must be sought, supposing the connection really to exist. Ehrenbaum remarks that the theory is equally consistent with his own view that the young

* Verslag Nederlandsche Zeevisschereien over 1886, Bijlage iv.

† Vol. i, N. S., p. 334.

anchovies observed by Hoffmann were in their second year. This is to some extent true, for if we suppose that in a cold summer many of the yearling fish would be starved or killed by the cold, of course fewer would survive until the fishery of the following summer, when they would reach the adult condition. But in this case the temperature of the summer two years before the fishery would also have a great influence, since the fish would then be hatched and reared, and Hoffmann's theory only refers to the immediately preceding year. Ehrenbaum mentions that Dr. Hoek has come to conclusions unfavourable to Hoffmann's theory, having found that the exceptions to it are very numerous. In fact, if we examine Hoffmann's records we find that though the years in which the fishery has been unusually productive have always been preceded by an unusually warm summer, the unusually warm summers have by no means always been followed by an abundance of anchovies. For instance, in the years 1861 and 1884 there was no great difference in the summer temperature; both were above the mean, while in 1862 the catch was 9,413 ankers, and in 1885 104,275 ankers. In 1883 the temperature was much below the average, and in the following year the catch was 30,318 ankers. If we compare the magnitude of the catch with the temperature in the same summer we find that a high temperature is usually accompanied by a small catch, and a low temperature by a large catch, and this rule seems to have as few exceptions as Hoffmann's. On the whole, it seems clear that the conditions which determine the number of anchovies which enter the Zuyder Zee are more complicated than Hoffmann's theory supposes, and that much labour and ingenuity will still be required before their exact nature and influence are ascertained.

Clupea alosa and C. finta, the Shads.

My attention was directed to the rate of growth of the anchovy and the shads by the perusal of Ehrenbaum's paper on the anchovy, to which I have already referred. With regard to the anchovy, I am in complete agreement with him; but he seems to me, in correcting Hoffmann as to the growth of that species, to have fallen into an equal error in the opposite direction with regard to the shad. He says there is one clupeoid, namely, *Alosa vulgaris* and *finta* (why he calls these two, one, I do not know), which, according to Metzger and Hoek, grows about as fast as the anchovy according to Hoffmann. Metzger supposes that the shads hatched at the end of May reach in the first autumn a length of 6·0 to 10·0 cm. Hoek found at the end of July young shads which were 4·5 cm. long. Ehrenbaum

himself has taken in the Elbe young shad of the following dimensions :

Middle of August	5·4—7·8 cm.
First week in October	6·9—8·6 „
Middle of October	7·7—9·6 „
Middle of November	8·0—12·4 „

Ehrenbaum calls these specimens *Finten*, so that I suppose they were identified as *Clupea finta*. He says that Hoek has recently altered his former opinion, and now concludes that these young specimens, which have already reached the permanent form, that is, have finished their metamorphosis at the end of July, cannot be derived from the spawn of the same year, but are already a year old, and Ehrenbaum agrees with him. He goes on to state that in the summer of 1891 he observed the spawning of the *Finte* in the Elbe in the second half of May, and then obtained eggs with well-developed embryos, and also larvæ with large yolk-sacs. Towards the end of May he captured numerous larvæ of 8 to 9 mm. in length, which retained a trace of the yolk, and on the 17th June larvæ of 9 mm. to 1·4 cm. He obtained no more larvæ, but in August got the specimens above mentioned, which were taken in nets, and were already fully scaled and had the form of the adult. He concluded from this that the young larvæ hatched in the river migrate to the sea as soon as the yolk has been absorbed, only returning to the river in the following year, at the size mentioned. This conclusion is obviously erroneous. Supposing all the specimens to belong to the species *Clupea finta*, though it is not proved that they were not *Clupea alosa*, we have to consider what is the size of the former species when full grown. Day says it attains to 16 inches in length, so that it is somewhat larger than the herring. Meyer has shown that the spring herring spawned in April and May, have by the end of July for the most part completed their metamorphosis, and are then 4·5 to 5·5 cm. long. What is there then to prevent the shad spawned in May from completing its metamorphosis by the middle of August, and reaching a length of 5·4 to 7·8 cm.? The herring, according to Meyer, is 8·4 cm. long and upwards by the middle of November, and yet Ehrenbaum maintains that specimens of the twaite shad, a larger fish when full grown, which are 8·0 to 12·4 cm. long in November, are eighteen months old. He compares his observations on the shad with Hoffmann's on the anchovy, and concludes that the shad takes eighteen months to reach the same length that the anchovy reaches in seventeen, regardless of the fact that the adult anchovy is scarcely half the length, and much less than half the weight of the adult twaite shad.

The observations and conclusions of Metzger and Hoek, to which Ehrenbaum refers, are contained in a Report on the *Ankerkuil* and *Staalboomen* fishery of the Hollandsch Diep, and Haringvliet,* which names are applied to different portions of the broadest estuarine channel at the mouth of the Maas or Meuse. In the Report itself observations on the young of *Clupea alosa* and *Clupea finta* are recorded in separate tables.

The observations of young *C. alosa* are—

Date.		Number.		Length.
April 27, 1887	...	15	...	10 —11·6 cm.
„ 27, 1887	...	25	...	9 —12·5 „
May 18, 1887	...	9	...	8·8—11·4 „
June 18, 1886	...	10	...	11·5—13·5 „
„ 18, 1886	...	8	...	11·0—12·0 „
„ 21, 1886	...	1	...	25·5 „
„ 22, 1886	...	4	...	9·6—13·6 „
July 28, 1886	...	1	...	16·0 „
October 21, 1886	...	8	...	7·2— 8·0 „
„ 21, 1886	...	7	...	7·5— 9·3 „
„ 21, 1886	...	20	...	9·0—11·3 „
„ 21, 1886	...	35	...	9·0—14·3 „
„ 22—24, 1886	...	3—25	...	5·8— 8·7 „
„ 23—24, 1886	...	5—9	...	7·2—10·0 „

The figures in the table do not exactly agree with those mentioned in the text (p. 121), although they apparently refer to the same observations; the differences are not great, but sufficient to puzzle the reader. In the text it is mentioned that specimens of 3·5 to 3·8 cm. in length were taken on 22nd and 23rd of July, 1886, and these are not included in the table at all. It is stated that the shad enters the river in April and May, that it is believed to spawn in the higher parts of the Rhine and its tributaries, but that it is not known whether some individuals may possibly spawn in the lower part of the river. The time of spawning is not absolutely ascertained; according to Kröyer and Nilsson the spawning takes place in June and July; according to Day between the beginning of May and the middle of June. It seems to me likely enough that the spawning may be continued from the end of April until July. Metzger and Hoek state that 60 and 70 cm. is no uncommon length for the shad, that is 2 feet and upwards. In the Report proper, the authors conclude that the fish of 3·5 and 3·8 cm. taken at the end of July were from the spawn shed the same year, and were therefore about two months old. Those taken in November under 6·0 cm. long are also supposed to have been hatched in the

* Published separately and also as Supplementband II of the Tijdschrift der Nederlandsche Dierkundige Vereeniging. Leiden, 1888.

previous spring. I find that the German version of the Report is not always an accurate rendering of the Dutch. As I understand the latter, it says (p. 120) that like most of those taken in October, November, April, and May, so also those taken in June, 1886, were derived from the spawning of the year preceding that in which they were taken; that is, they were a year old or more. But the question is raised whether the fish of 7·2 cm. taken in October were of the same age as those 14·2 cm. taken in the same month.

My own opinion is that the specimens taken in April, May, and June, except the one 25·5 cm. long, were about a year old, having been hatched in the spring of the preceding year; but I cannot help thinking that these were all unusually small specimens, which had not reached the normal size of yearling shad. Hoek and Bottemane themselves estimate the age of specimens 25 to 31 cm. in length, taken in May, June, and July at two years, and, according to this specimen, one year old ought to be about 17 to 20 cm. in length. I consider that the specimens taken in October and November are all derived from the spawning of the spring of the same year, not, as the authors conclude, from the spawning of the preceding year.

The observations on *Clupea finta* in the same Report are tabulated as follows:

April 27, 1887	...	93 specimens	...	8·9— 9·2 cm. long.
May 18, 1887	...	4 ,,	...	7·2— 8·4 ,, ,,
June 18, 1886	...	8 ,,	...	7·7—10·0 ,, ,,
,, 18, 1886	...	1 ,,	...	8·9 ,, ,,
,, 18, 1886	...	3 ,,	...	9·7 ,, ,,
,, 22, 1886	...	6 ,,	...	9·1—11·2 ,, ,,
,, 22, 1886	...	13 ,,	...	10·5—12·0 ,, ,,
October 4, 1886	...	5 ,,	...	9·0—11·5 ,, ,,
,, 21, 1886	...	12 ,,	...	6·7— 8·9 ,, ,,
,, 21, 1886	...	3 ,,	...	6·3— 8·7 ,, ,,
,, 21, 1886	...	17 ,,	...	9·0—15·0 ,, ,,
,, 21, 1886	...	18 ,,	...	10·0—12·3 ,, ,,
,, 22—24, 1886	...	27 ,,	...	5·4—10·0 ,, ,,
November 23—24, 1886	...	3—8 ,,	...	5·8—10·4 ,, ,,

The special discussion of these observations is given in the Report proper. My own interpretation is that all those in the first of the two parts into which I have divided the table are from the spawning of the previous year, while of those in the second part of the table the greater number are from the spawning of the preceding spring of the year in which they were captured. The largest of those taken in October, those over 12 cm. in length, may very possibly be in their second year.

In an appendix to the report by Hoek, specially devoted to the fish larvæ and young fish observed, that zoologist gives reasons

which incline him to modify the opinion expressed in the Report proper concerning the age of young fish about 4·5 cm. long, which already had acquired the permanent form of the adult, and which were taken towards the end of July, 1886. The length of these fish is given in the body of the Report as 3·5 to 3·8 cm. Hoek argues that if the shad (*C. alosa*) spawns, as Kröyer and Nilsson say, in June and July, these fish must be a year old, and mentions in support of the latter conclusion that the sea-herring takes seven to nine months before it undergoes its metamorphosis from the larval form to that of the adult. This latter fact is taken by Hoek from the results of Meyer and Heincke, published in the Reports of the *Commission zur Untersuchung der deutschen Meere in Kiel.* But it seems to me that, in the first place, Hoek has somewhat exaggerated the statements of Meyer and Heincke. It is true that the latter observers found that some herring larvæ hatched in autumn and winter did not attain to the perfect form until June and July; but the German investigators do not suggest that the eggs from which these larvæ came were shed in October, but later in November and December; and Meyer further points out that the water is then very cold, and that the eggs take many weeks to hatch, so that the larvæ taken in June are more probably four or five months old, reckoning from the time of hatching, than seven to nine months. Another important consideration overlooked by Hoek is that these larvæ of the autumn, or sea-herring, are 5 to 6 cm. long before they have completed their metamorphosis, while the young shad to which Hoek refers had already attained to the perfect and permanent form at 4·5 cm. What probability is there that the young of so large a fish as the shad when 4·5 cm. long should be five to seven months older than the larva of a herring 5 to 6 cm. long? Then again the shad is hatched in spring in warm water, why then should its growth be compared with that of the winter herring, whose eggs and larvæ are produced at the coldest time of the year, rather than with the growth of the spring herring?


Map of the
BRITTANY & VENDÉENNES COASTS
FRANCE
Showing the Fishing Grounds & Factories
OF THE
SARDINE INDUSTRY.
Indicates the Principal Centres
of the Industry.
FINISTÈRE
CÔTES DU NORD
MORBIHAN
ILLE ET VILAINE
LOIRE INFÉRIEURE
VENDÉE
SARDINE FISHING GROUND
LIEUX DE PÊCHE
Brest
St Brieuc
Chateaulin
Quimper
Lorient
Hennebont
Vannes
Redon
Paimbœuf
Nantes
Belle Isle
Palais
Ile de Croix
Rade de Quiberon
Ile de Noirmoutier
Ile d'Yeu
La Roche S Yon
Les Sables d'Olonne
Ile de Ré
La Rochelle

On some Young Specimens of Centrolophus pompilus (Art.) from the Coast of Cornwall.

By

Ernest W. L. Holt.

On the 24th June, 1891, a mackerel boat, which had been fishing off the Runnistone, brought in several fish of the above species. They excited a good deal of interest among the local fishermen, to whom they were quite unknown. A coastguardsman, who had seen them abroad, I forget where, declared them to be "pilot-fish," a diagnosis with which some of the fishermen, to whom the true pilot-fish, *Naucrates ductor*, appeared to be known, could by no means agree. It appears, however, that from a certain similarity of habits the name is occasionally applied to the form before us, usually known to British naturalists as the black-fish.

I believe that about six or eight black-fish were brought ashore on this occasion, of which, by the kindness of Mr. J. C. James of Newlyn, I managed to secure four. They were all small specimens, the total lengths being $13\frac{3}{4}$ inches, $13\frac{1}{2}$ inches, $12\frac{5}{8}$ inches, and $12\frac{5}{8}$ inches. Before preserving them I examined the contents of their stomachs, which consisted of a considerable number of young pollack, about 3 inches long; in fact, the stomachs were quite distended with them. I also endeavoured to ascertain their sex, and concluded that they were all immature males. Hermaphroditism has been recorded by Syrski in this species (cf. Max Weber, U. Hermaph. b. Fischen. Ned. Tijdsch., Jaarg. v, 1884, p. 37),* but it does not appear whether this is a normal or abnormal condition.

The colouration of the black-fish appears to be highly variable. Couch draws special attention to this point, noting the difference between Risso's description of Mediterranean specimens and the condition in British examples that had come under the notice of himself and earlier observers. That this, however, is not wholly attributable to climatic influences, as Couch seems to have supposed, may be inferred from an examination of Bonaparte's figure (Faun,

* I am indebted to Prof. G. B. Howes for this reference.

Ital. Pesc.), in which the colours are shown nearly as dark as those met with in British specimens. Indeed, the colours in my own specimens bear a closer resemblance to those in Bonaparte's figure than to the condition described by Couch, and the dull neutral hue shown in his figure (British Fishes, vol. ii, pl. xc) is altogether wanting, though the example from which it was drawn was about the same size as my own. Of the uniform brown colour, stated by Day (Fish. Gt. Brit., vol. i, p. 112) to be usual in this species, there is no trace; but Buckland's description is fairly applicable.

The following notes were taken before the fish were placed in spirit. In the two larger specimens the head is a very dark violet-grey above, minute lighter specks marking the muciferous pores; between the eye and the upper jaw the colour is sapphire blue,* due to irridescence, with grey pores. Similarly, the under side of the head is blue, dark grey bands marking the course of the hyoid and the edge of the opercular membrane. The iris is white, speckled with grey, becoming yellowish towards its inner margin, and grey towards the circumference. The gill covers are dark violet-grey with lighter streaks. The body is a violet black along the dorsal region, shading very gradually to a silver grey ventrally, almost white on the ventral surface of the abdomen. Small ovoidal silver-grey flecks occur on the sides above and below the lateral line, most abundantly in the deepest region of the fish, *i. e.* at about the level of the commencement of the dorsal fin. In the largest of the two specimens these flecks are very faintly marked.

The dorsal fin is black, dotted with minute grey specks about the base, due to the fact that the scales covering this region are grey with black edges. No such conspicuously lighter band, as is shown in Day's figure (op. cit., pl. xl, fig. 2), occurs in any of my specimens. The base of the pectoral is grey, the distal region black. The pelvic has black rays, and a bluish-grey membrane. In the anal, the basal region is silver grey, shading into black at the distal margin.

The colours of the two smaller specimens agree generally with the above description, but are paler. In one, the greater part of the body below the lateral line is silver grey. There is no blue iridiscence on the cheeks of either, and the lower jaw is very pale and lacks the darker bands. The flecks on the sides are more plainly marked than in the larger specimens, and are probably of a transitory nature, disappearing as the fish increases in size. Day notes that these markings, which he describes as yellow, are absent in some specimens, but does not mention the sizes of the fish he

* Couch notes that whilst he was drawing his specimen the side on which it was laid turned to a fine blue.

examined. Risso speaks of young examples having dark transverse bands, so that it appears that, as is usual in fishes, there are several phases of colouration.

The records of the occurrence of the black-fish on the British coasts, as collated by Day, are pretty numerous, the greater number having come, like the specimens before us, from the coast of Cornwall; from the same authority we learn that its range extends southwards to Madeira, and into the Mediterranean, whilst it has occurred so far north as the coast of Northumberland.

Day quotes an interesting observation of Mr. Dunn, that of about a dozen taken near Mevagissey, every one could be traced to the neighbourhood of a large fish, generally a shark. The only shark that I heard of was a young thresher, *Alopias vulpes* (Gmel.), about 15 feet long, which was brought into Penzance a few days previously from the neighbourhood of the Scilly Islands, and exhibited in the market at a penny per head as a young whale. The Runnistone is no great distance from the Scillies, but six or eight black-fish seem rather a large escort for one shark, and it might be supposed that the habits of the thresher would render it a companion more lively than agreeable. It may be mentioned that the stomach of the thresher contained about a bucketful of pilchards.

Experiments on the Relative Abundance of Anchovies off the South Coast of England.

By

W. L. Calderwood,
Director of the Laboratory of the Marine Biological Association.

By a resolution of the Council of the Association, passed on the 25th March, 1891, it was determined to proceed as speedily as possible with the inquiry into the relative abundance of anchovies on the south coast of England.

Mr. Cunningham* had already drawn attention to the presence of anchovies, had described their specific characters and habits and recorded the various "takes" which had come more especially under his notice. It was shown that at Dover the sprat fishers captured very considerable numbers; that at Torquay, one fifth of the fish, taken in the sprat nets, consisted of anchovies, and that off Plymouth and the fishing ports of Cornwall the fish were already fairly well known.

Men fishing for pilchards, herrings, and mackerel, occasionally found anchovies entangled in their nets, and since no net was used of a mesh small enough to catch them in the proper manner, it was very naturally supposed that, given a net of the correct mesh, anchovies might be taken in such numbers that a regular fishery could be established.

On this account, therefore, the Council determined to make the experiment, and Mr. Cunningham and myself took the work on hand at once.

In order that we might have a thorough knowledge of the various methods employed in the capture of this fish in other countries, I wrote to Prof. Marion, of Marseilles, Señor Vale, of the Spanish Fishery Department, Madrid, and to Dr. Eisig, of Naples.

Mr. Cunningham had previously written to Dr. P. P. C. Hoek, of Helder, Zuyder Zee.

* *Anchovies in the English Channel*, Journal of the Marine Biological Association, vol. i (N.S.), pt. iii, p. 328.

In each case I received a most courteous reply giving all the information desired.

On the south of France the anchovy is fished in the same way as the sardine, by means of the drift-net. Each boat carries 200 fathoms of net made up of four pieces. Each piece or *band* is from 8 to 10 or 12 metres wide. The mesh varies slightly in each band, the largest being sixteen to the *pan* (a pan being equal to ·25 metres) the smallest—in which the anchovies are taken—eighteen to the pan. The net is shot at a great distance from the shore and the boat made fast to it as in this country. A net of this description costs 1200 francs (£50).

On the south coast of Spain anchovies are fished for in two ways, one a drift-net method similar to what has already been described, the other by using a seine-net worked in shallow water, the shoals of fish being surrounded and dragged on shore.

Signor Raffaele, writing from Naples, also describes a drift and a seine-net in use round the coasts of Italy and Sicily. The drift-net is 600 metres in length and 20 to 30 metres in height (say 656 × 26 yards). It is shot in a line parallel to the shore, and can be arranged at different depths, towards the surface at night and in the early morning, but at a greater depth during the heat of the day. It is composed of three pieces, and has a mesh varying from 1 to 2 cm.

The drift-net may therefore be considered the most important system in France, Spain, and Italy, the seine-net being used as a convenient method when a sandy shore exists.

Raffaele adds that pilchards are taken along with anchovies by the shore seine-nets of Italy.

In the Zuyder Zee, where the water is very shallow, three methods are used. A long net only about four feet deep, having the ends kept extended by means of poles, is moored in favourable localities. In order that it may maintain its proper position it is corked and leaded in the ordinary manner. Near Bergen op Zoom immense screens are constructed of willows and poplars. These appear to act similarly to leaders in a salmon bag-net, as openings at certain places allow of the anchovies being netted. Also a curious kind of trawl is used. The net is similar in shape to an otter-trawl or Thames stow-net. It is dragged along by two boats sailing a parallel course before the wind.

Considering the conditions existing in the south-west coast of England we decided upon the drift net as being the most likely to render good results, and, having received estimates for the making of an anchovy net, I ordered from Mr. Matthias Dunn, of Mevagissey, five nets, each to be 120 yards long and 30 score deep

= 60 fathoms × 5 fathoms, with sixty-four rows to the yard—bringing the mesh a trifle over half an inch.

Our whole net, then, was about 50 yards shorter than that described for the south of France by Prof. Marion, but was 30 feet deep, while the French net is only about 11 feet. When corked and leaded, complete, and ready for use the net cost £62 10*s*.

The order was given on the 12th May, 1891, and the net received on the 26th of August.

The autumn and summer seasons, as everyone knows, were extremely unsettled, and the long-continued gales often rendered fishing quite impossible for several weeks at a time. We, therefore, had a most unfortunate start in this our attempt to ascertain if it was possible to institute an entirely new fishery for England. For instance, on receiving reports that anchovies were seen off Mevagissey, in Cornwall, I sent a boat at once, but a gale springing up just before the destination was reached, the anchovies disappeared, and a week was spent lying wind-bound in harbour. During very many weeks the boat could not leave Plymouth on account of heavy weather, and often when the attempt was made it was found impossible to shoot the nets.

The first trial was made on the 4th of September, 1891, and the nets were finally taken on shore on 14th January, 1892. During that period the nets were shot twenty-two times. The results yielded considerable numbers of sprats, pilchards both large and small, a few mackerel and herring, but anchovies only in limited numbers.

That several shoals of anchovies were present I feel satisfied, on account of the numerous reports received, accompanied in many cases by specimens.

To aid us in determining the best localities, I put an advertisement up on the fish quay, asking that information might be given to the fishermen of the Association when anchovies had been seen or caught. In my record of the anchovy experiments I come upon many entries relating to reports of this kind, and after deducting a proper percentage for the somewhat large grain of salt with which almost every fishermen deems it necessary to flavour his remarks, I am inclined to come to the conclusion that, although our own fishing proved unsuccessful from a commercial point of view, there were nevertheless large shoals of anchovies off the coast of Devon. To take an extract from my diary:

"November 9th. Roach reports this morning that a boat fishing mackerel on Saturday night (7th) about twenty miles south of Salcombe, caught 20,000 mackerel, 1000 Acanthias, and was amongst anchovies in such numbers that a net to mesh them could not have

been taken on board. The skipper's remark was that 'you could have loaded a ship with them.'

"Received twenty anchovies from another boat, fishing a little further west." And again:

"November 21st. Mayflower out fishing four miles west of Eddystone. Took twenty anchovies large, ... using our nets. Boats fishing pilchards closer inshore took anchovies in considerable numbers. . . . . A boat fishing herring close to where our nets were shot took 100 anchovies."

An interesting point is the enormous size of the anchovies on our coasts. The following figures will suffice to give an idea of the large fish met with. It is the record of the catch in which our largest anchovy was taken, and I am not aware that any anchovy of such a size has ever been previously recorded.

The largest was $8\frac{1}{8}$ inches long and measured $3\frac{1}{4}$ inches in girth, the other measurements are in inches.

$7\frac{1}{3}$	...	$7\frac{1}{2}$	...	$6\frac{3}{8}$	...	$7\frac{1}{4}$
$7\frac{1}{2}$	...	7	...	$7\frac{3}{8}$	...	$7\frac{5}{8}$
$7\frac{1}{2}$	...	7	...	$7\frac{1}{2}$	...	
$7\frac{3}{4}$	...	$7\frac{3}{8}$	...	$7\frac{1}{8}$	...	
$6\frac{3}{4}$	...	$7\frac{3}{4}$	...	$7\frac{3}{8}$	...	

The smallest anchovy captured was about the size of those usually found in bottles and tins of the retail dealer; it measured a trifle over 5 inches ($5\frac{1}{10}$). The average size is $7\frac{1}{4}$, yet in the previous year so many were brought to the Laboratory measuring only 5 or $5\frac{1}{4}$ inches, that the average then must have been considerably less.

An interesting feature in the use of the small meshed nets was the capture of small pilchards or sardines. Mr. Cunningham has prepared a statement upon them which will be found in his paper in this number, under the title *Rate of Growth of some Sea Fishes* (Section *The Pilchard*, p. 244).

In reading this account of our endeavours it must be borne in mind that in a expanse of open sea like the English Channel, one boat with one net runs a comparatively poor chance of meeting with great success. Men fishing for herring or mackerel have the assistance, it may be, of three or four hundred crews in enabling them to find out where the fish are, and where they are not. We, on the other hand, were looking for fish which no one else was looking for, and had to grope in the dark. It appears, however, that November is the month during which most anchovies will be found off the coast of Devon and Cornwall, and as the autumn season arrives we shall hope to try again with greater success.

Report on Physical Investigations.

By

H. N. Dickson, F.R.S.E.

The unusually severe weather of the last eight months has made it impossible to continue the observations in the Channel with any degree of regularity; only two trips have been made since that in June, of which a preliminary report was published in the last number of the *Journal*. The first of these, in November, included station VIII of the previous cruise, off the Bill of Portland in mid-channel, and the previous stations XIII and XIV, in Start Bay, also station I off Bolt Head. Besides these, soundings were taken at an additional station in mid-channel, south of Start Bay, and at four points in Start Bay itself, near land. The cruise was unfortunately interrupted by a gale which necessitated taking shelter for thirty-six hours in Portland Roads.

The second trip was made on March 1st and 2nd, with the view of obtaining temperature observations as nearly as possible at the annual minimum. After sounding at stations I and XIV, and making an unsuccessful attempt at station XIII, we were again compelled to return to Plymouth by unfavourable weather.

As regards temperature observations, the additional data show that in November the distribution is extremely uniform, and in general the temperature is rather more than 2° F. warmer than in June. In March, again, the few observations obtained indicate a general fall of about 8° F. since November. In neither case was the abnormal distribution found in Start Bay in June reproduced (see previous paper, *Journal* M. B. A. ii, 2, p. 159) and its reappearance next summer may be looked for with interest, as it seems to suggest that in the western portion of the Bay, a large mass of water is partially cut off from the general circulation, and subjected to the heating action of the sun's rays without mechanical mixing.

During the cruise in November, sixteen samples of bottom and

surface water were collected. These have been subjected to the most careful examination of which the resources of the Laboratory will permit. The total halogen, calculated as chlorine, and the alkalinity of each sample has been determined, as well as the density both by Buchanan's hydrometer and the Sprengel tubes. The examination of these samples has shown that the water over the area under consideration is normal Atlantic water throughout. The mean value of "D" *i. e.* the ratio of the excess of density of sea-water at 0 °C. over that of distilled water at the same temperature, to the amount of chlorine in the sea-water, is 1·4553, with the limits 1·450 and 1·457, a result in complete accordance with the value found by Dr. Gibson for what he believed to be Atlantic water, contrasted with water from other areas, as for example the Arctic Ocean, which gave a markedly higher value. The close agreement of these determinations, made under considerable disadvantages, affords strong proof of the importance of a thorough examination by a chemical specialist of a limited number of samples of water from the great oceans of the globe. It seems possible to determine, once for all, the values of D for each of the great oceanic basins, and from these to ascertain at any time the source of supply of special currents in any particular area.

The chlorines of twenty-seven of the samples collected in June last were determined before the publication of the previous paper, but were not included in it, as it was then intended to make a series of density determinations with the Sprengel tubes. It was, however, found impossible to make these determinations, and a comparison was therefore made between the Sprengel tube determinations of the second series and the densities of the same samples as found by the hydrometer, reduced to 15·56° C. as compared with pure water at 4° C., and then again reduced to 0° C. and referred to pure water at 0° C., by the help of Dittmar's tables. The results thus calculated differed from the Sprengel-tube values by $-0{\cdot}00013$, giving a correction almost identical with Dittmar's "hydrometer error." It would seem, however, that the numerical agreement is accidental, and these experiments have led to a more extended investigation at present in progress. Accepting the correction $+0{\cdot}00013$ for the present, and applying it to the hydrometer determinations of the June samples, the mean value of D is 1·4550 with the limits 1·453 and 1·457, a further confirmation of Dr. Gibson's results.

So far as the present inquiry is concerned, it may therefore be assumed that the water of the English Channel is Atlantic water pure and simple, and the alkalinity determinations do not show any variation in its "strength" by dilution with fresh water or otherwise. The chief interest accordingly centres round the temperature

observations, which although already very suggestive, are still too few in number to merit detailed discussion.

Considerable progress has already been made in collecting material for investigating the mixture of waters in the local estuaries at different states of the tide, but the results are not yet ready for publication.

Meteorological Observations at M.B.A. Laboratory, Plymouth, 9 a.m. and 9 p.m.

{ Lat. 50° 21′ 49″ N. / Long. 4° 8′ 21″ W. }

Height of cistern of barometer above mean sea level 125·93 feet.
" rain gauge " " 117·67 "
" " " ground 0·62 foot.

Month.	Mean barometer at 32° F. and sea level.	Temperature.				Dew point	Elastic force of vapour.	Relative humidity per cent.	Wind.										Cloud amount mean.	Sun-shine hours.	Ozone 0—10.	Rainfall inches.	Rainy days.	Rainband 0—8.
		Mean max.	Mean min.	Dry bulb.	Wet bulb.				Direction. No. of days. N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	Mean force, 0—12						
1891																								
October .	29·727	57·1	46·7	52·0	49·6	47·3	·331	84·6	2	6	1	2	7	7	3	1	2	2·7	5·5	118·68	4·5	8·385	21	—
November .	29·831	50·4	41·1	45·2	43·6	41·6	·268	87·5	8	7	1	1	3	6	2	1	1	1·8	6·5	59·57	4·4	4·190	19	3·3
December .	29·993	50·0	42·1	45·8	44·4	42·7	·284	89·5	2	1	2	3	4	10	4	2	3	2·5	6·6	55·32	5·6	5·170	23	3·4
1892																								
January .	29·924	44·6	36·0	39·6	38·2	36·2	·217	87·8	4	7	0	2	1	5	6	4	2	1·3	6·5	67·79	4·5	1·866	12	2·9
February .	29·802	47·1	38·8	42·5	40·7	38·3	·238	85·9	3	6	2	4	3	4	2	3	2	1·9	6·8	86·17	4·1	3·120	15	3·1
March . .	30·023	45·4	34·5	39·5	36·4	32·0	·187	75·0	1	16	5	1	2	2	1	0	3	1·2	5·4	157·70	4·6	1·171	7	—

Observations of the Temperature of the Surface of the Sea off Plymouth.

The observations given below are by Mr. William Roach (Series I), Associate Member M. B. A., and by Mr. H. Roach (Series II), the fisherman of the Association. The observations are taken partly in Plymouth Sound and partly on the fishing grounds a few miles to the eastward. A careful comparison of the two sets during the same periods does not show any *local* differences, and as the observations are true sea temperatures throughout, it is unnecessary to state the positions more definitely.

It has been thought best to give the results in the form of ten-day means, as being most convenient for use in connection with fishery statistics.—H. N. Dickson.

	Series I.		Series II.	
Date.	No. of obs.	Temp.	No. of obs.	Temp.
1891.				
July 21—30 ...	18	57·4°		
July 31—Aug. 9	15	57·2		
Aug. 10—19 ...	18	58·0		
Aug. 20—29 ...	18	58·8		
Aug. 30—Sept. 8	13	58·9		
Sept. 9—18 ...	18	58·7	7	58·6°
Sept. 19—28...	11	57·9	6	58·0
Sept. 29—Oct. 8	9	57·4	7	57·3
Oct. 9—18 ...	3	56·8	4	56·6
Oct. 19—28 ...	8	54·4	9	54·1
Oct. 29—Nov. 7	9	52·1	7	52·9
Nov. 8—17 ...	8	50·3	5	51·8
Nov. 18—27 ...	6	52·7	5	51·8
Nov. 28—Dec. 7			3	49·8
Dec. 8—17 ...			4	49·4
Dec. 18—27 ...				
Dec. 28—Jan. 6				
1892.				
Jan. 7—16 ...	9	45·8	6	46·8
Jan. 17—26 ...	15	44·8		
Jan. 27—Feb. 5	2	46·5	8	46·5
Feb. 6—15 ...	15	46·4	7	46·7
Feb. 16—25 ...	10	44·1		

Monthly Reports on the Fishing in the Neighbourhood of Plymouth.

By

W. L. Calderwood,
Director of the Laboratory of the Marine Biological Association.

Introductory Statement.

In these reports I shall not take into consideration the minor methods of fishing which are practised in the locality, such, for instance, as eel spearing, mullet trapping, shrimp and prawn fishing, but shall confine myself to the most important branches, in which the beam trawl, drift and seine nets, and long lines are employed, and I shall also include crab and lobster fishing.

With reference to the class of boats employed in this neighbourhood, the **trawlers**, compared to those of the North Sea, are not of large size. The average boat is about forty-three tons. They are usually rigged as ketches (dandy-rig), but the smaller ones sometimes as cutters. The dandy-rig is preferred because with it there is not the very large mainsail and heavy boom of the cutter, and also because, like the yawl, where the mizzen mast is stepped behind instead of before the stern-post, the vessel can be more easily brought under easy canvas in heavy weather. These vessels only carry four men and a boy as crew, and therefore the question of ease in handling becomes one of great importance. Steam trawling is not practised from Plymouth, nor do the sailing trawlers fish in the "fleeting" system common in the North Sea, where many boats belong to one company and remain on the fishing grounds it may be for weeks, while their fish is carried to market by special steamers.

At Plymouth each trawler is worked independently, goes out to the fishing grounds east of the Eddystone, Mounts Bay, or Bristol Channel, and returns with its catch. The mesh of the trawl-net varies from four inches at the mouth to an inch and a half at the cod end, and therefore can take very small fish.

The boats using **drift-nets** for catching herrings, mackerel, and pilchards, are invariably rigged as luggers. They are of various sizes, not exceeding twenty-five tons. The nets for mackerel, set by one boat, may reach two to three miles, but the pilchard and

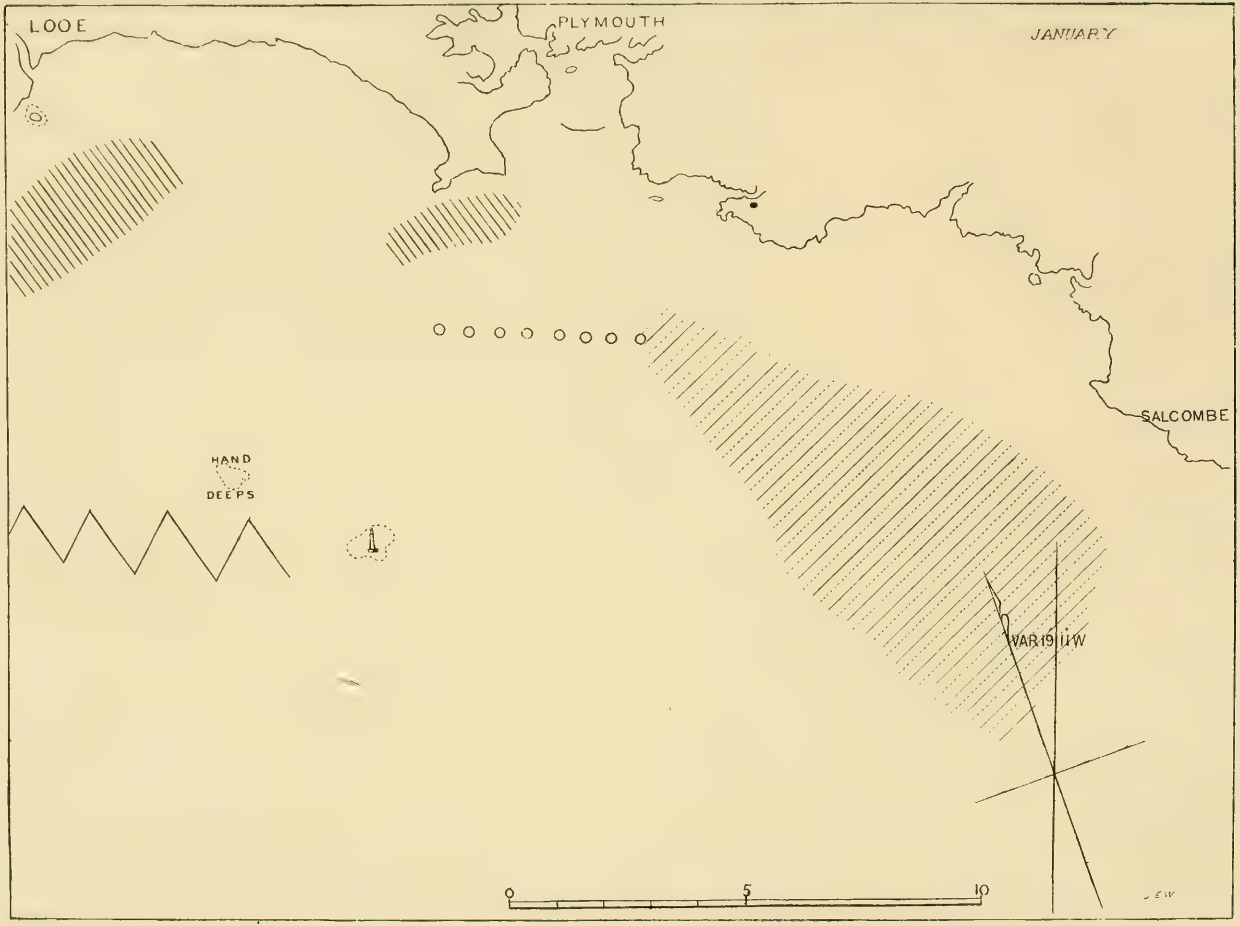
herring nets are smaller, and do not much exceed one mile in length. The large luggers carry five men and a boy.

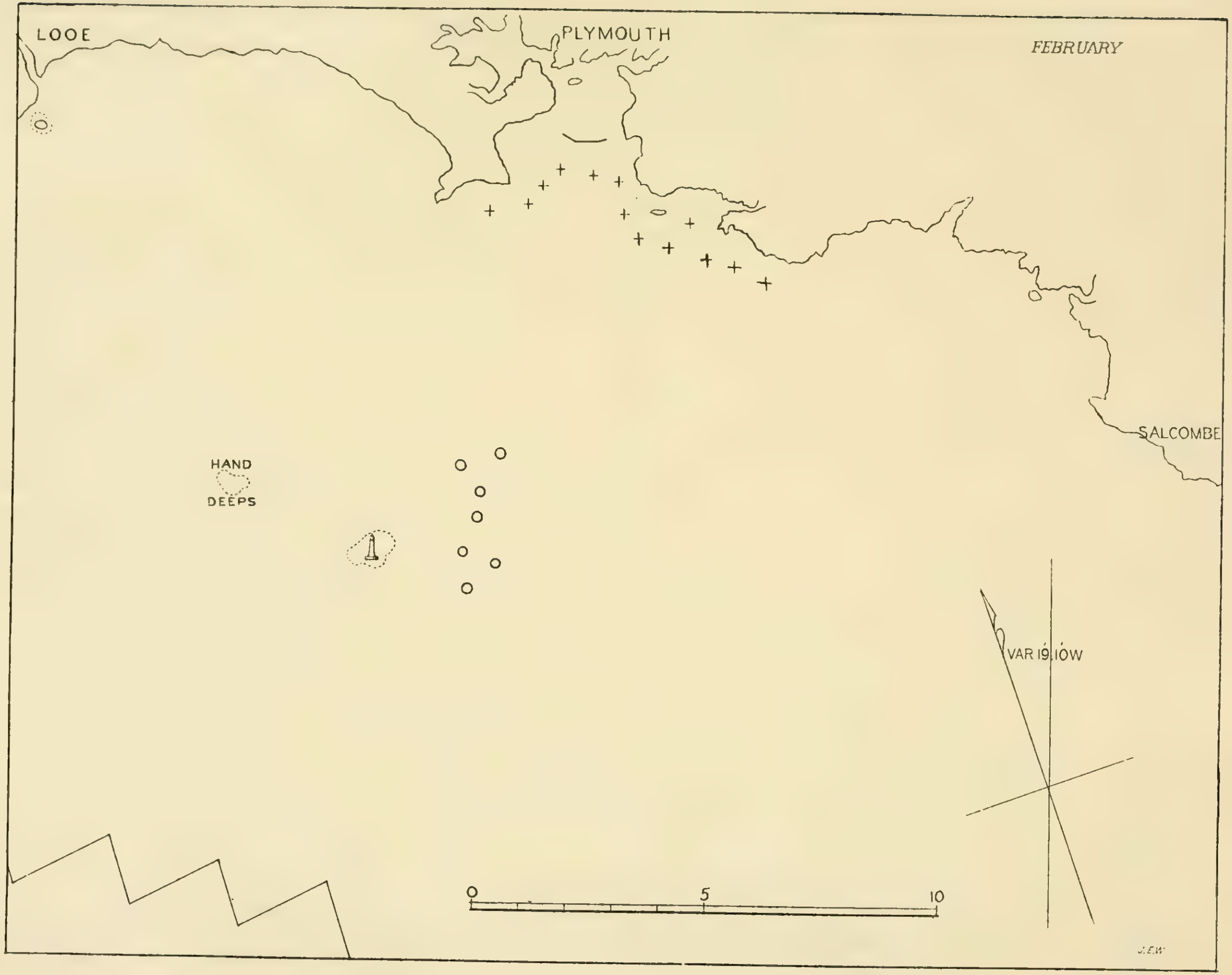
The boats employed in long-line fishing, or, to use the local term, in "bultering," are the most numerous. They are rigged either as luggers or cutters, a mainsail without a boom always being used in the latter case, and vary from twenty-five tons down to quite small rowing boats. A certain intermingling of classes takes place between the long-line boats or "hookers" and the drift-net boats, because at certain seasons a large lugger may fish by net and at another by line. In this case she carries the same crew for working the lines as she did when employing nets. A boat, however, which carries a large fleet of mackerel nets seldom has a long line on board at the same time. She may abandon one style of fishing and take up the other, but it is reserved for the herring and pilchard boats to carry both at the same time and set either. The boats which use only the long line and never venture far out into the open Channel after the shoals are of about twelve tons. These form the class of hookers proper, and work round the Hand Deeps and Eddystone. After them comes the swarm of little boats which may use set-lines, hand-lines, moored herring-nets, or shrimp trawls; but of all the boats fishing out of Plymouth the small hookers probably render the best account of themselves, not only because the price of the "take" has to be divided amongst fewer hands, but because the expense of keeping up a small boat of the kind required is comparatively insignificant; and, since they do not go far from land, the fish can be more quickly caught and put in the market.

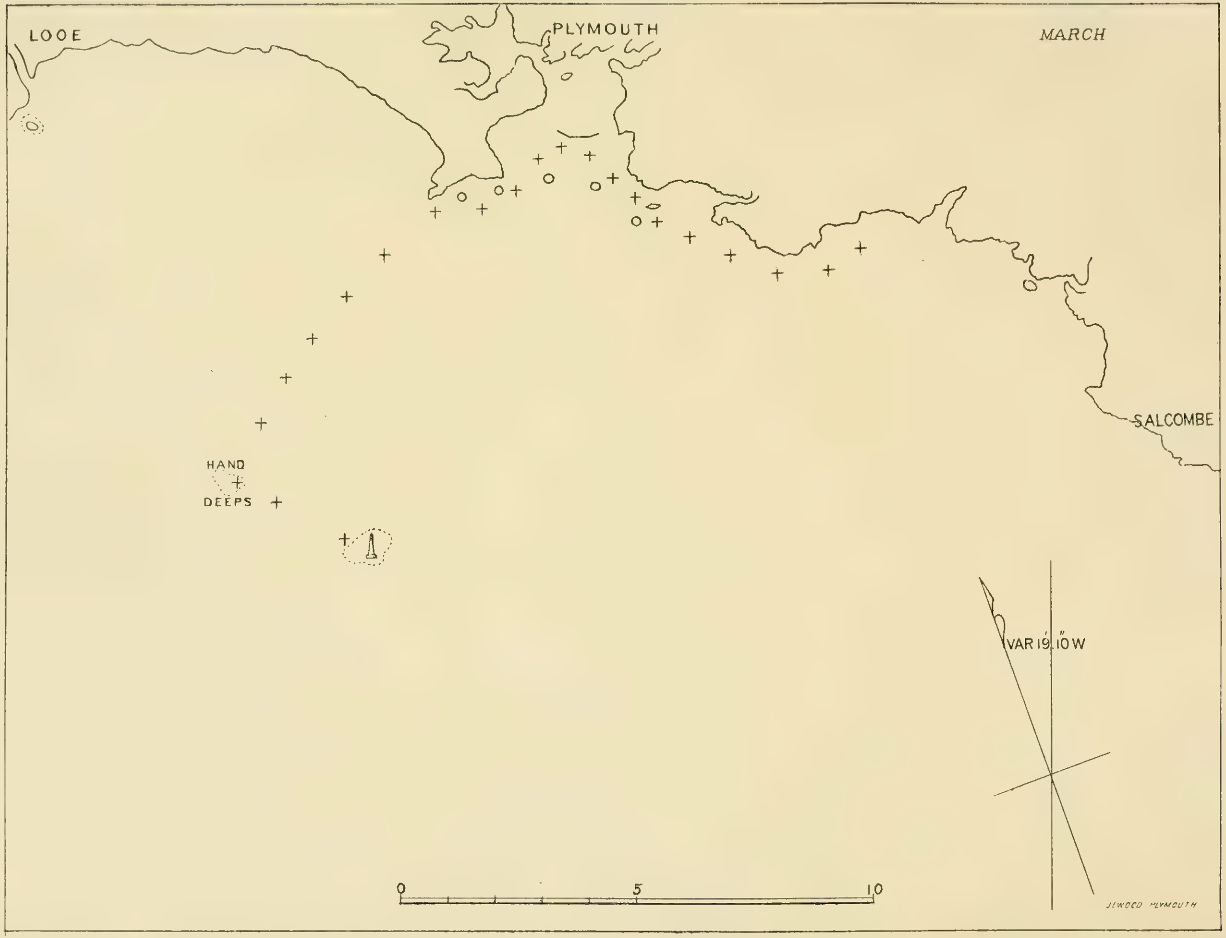
For Customs purposes the limits of the port of Plymouth are from the river Erme, eight miles east of Plymouth Sound, to the river Seaton, ten miles west of Plymouth Sound. In this district there are 257 boats registered under the Sea Fisheries Acts. 180 belong to Plymouth proper, 10 to Stonehouse and Devonport, 29 to Cawsand, and 38 to Yealm. The boats are registered as follows:

Trawlers	72
Drift-net boats . . .	36
Hookers	149
	257

The fishing-boat harbour at Plymouth is, however, never without a considerable number of boats hailing from other ports. Brixham trawlers fishing in the west, or round in the Bristol Channel, land their fish here; and any Grimsby, Yarmouth, or Lowestoft boats, fishing on the south coast, find their market and harbour at Plymouth.


LOOE
PLYMOUTH
JANUARY
SALCOMBE
HAND
DEEPS
VAR 19 11 W
0
5
10


LOOE
PLYMOUTH
FEBRUARY
SALCOMBE
HAND
DEEPS
VAR 19.10W
0
5
10


LOOE
PLYMOUTH
MARCH
SALCOMBE
HAND
DEEPS
VAR 19.10 W
0
5
10
JEWOOD PLYMOUTH

It is in the winter months, however, when the herring and mackerel season is at its height, and the Cornish boats arrive from Fowey, Looe, and Penzance, that the neighbourhood of Plymouth assumes its busiest aspect. The drift-net fleet alone is then composed of between three and four hundred sail.

In order that the fishing prosecuted around Plymouth may be known, and the various fishing grounds worked upon at different times of the year clearly demonstrated, I have thought it advisable to attempt the construction of monthly charts, each one showing, as nearly as possible, the average condition for that month. It must, of course, be understood that in these charts it is impossible to show all the minor fluctuations of the fishing.

There must always be a certain number of boats which, not succeeding in one place, try others, it may be far removed from the locality in which the majority of boats are fishing; or the shoals of fish themselves may suddenly alter their positions, so that the boats have for some days to scatter in all directions in search of them. Still, the fishing of one month is so distinct from that of another, and the alterations take place in such regular order, that it seems to me to be quite possible to construct charts which will represent exactly what grounds may be expected to be worked over in any particular season.

In this, the first attempt at anything of the kind for this locality, I do not say that the markings or positions of the various fishing boats may require no alteration, since it is possible or probable that some exceptional condition may be included in what is only meant to be an average condition; but a basis will, at all events, have been constructed from which to work.

Key to Symbols used in Monthly Fishery Charts.

////////	=	position of herring boats.
	=	,, of mackerel boats.
\\\\\\\\	=	,, of pilchard boats.
/\/\/\	=	,, of trawlers.
o o o o	=	,, of whiting boats.
+ + + +	=	,, of crab and lobster boats.

NOTES AND MEMORANDA.

The *Bulletin of the United States Fish Commission* for 1889 contains a report upon a physical investigation of the waters off the southern coast of New England in the schooner *Grampus* during the summer of 1889, by Professor W. Libbey of Princeton College. This forms the first instalment of a series which promises to throw much light on the relations of temperature and salinity to the distribution of fishes and their food, and was itself directly suggested by researches upon the shad and the menhaden.

The observations cover the area between lat. 39° N. and lat. 41° 10′ N., and long. 70° W. to long. 71° 30′ W., soundings being obtained as nearly as possible every 10′ along lines 10′ apart. At each station a very complete series of temperature observations was made, and samples were collected at surface, bottom, and in the deeper soundings at an intermediate point. The specific gravities of these samples were determined by means of a Kilgard salinometer.

The temperature profiles along meridians of longitude are of great interest, extending as they do from near the coast over the edge of the continental plateau into deep water. The bathy-isothermal line of 50° F. shows a remarkable curvature off the continental platform, which the report says "would seem to point to a mechanical intrusion of cold water from the surface of the continental platform." The conclusion is confirmed by the specific gravity observations; and the report goes on to say, "The existence of this body of warm water off the continental edge may offer an explanation of the richness of this particular spot in all forms of marine life, as shown by the successful dredging of the *Albatross* upon it."

It is much to be desired that the samples collected should be subjected to analytical examination, and to more refined determinations of density, as in this case it is of the first importance to identify the waters surveyed, and it seems likely that two distinct kinds are present.—H. N. D.

The following papers contain the results of work done at the Plymouth Laboratory and published elsewhere than in the Journal of the Association during the two years last past. They form a

continuation of the list published in Journ. Mar. Biol. Ass., i, pp. 364, 365.

Benham, Dr. W. B.—"The Nephridium of Lumbricus and its Blood-Supply, with Remarks on the Nephridia of other Chætopoda," Quart. Journ. Micr. Sci., xxxii, 293.

Cunningham, J. T.—"On some Disputed Points in Teleostean Embryology," Ann. Mag. Nat. Hist., 1891, 203.

Cunningham, J. T.—"An Experiment concerning the Absence of Colour from the Lower Sides of Flat Fishes," Zoologischer Anzeiger, 1891, 27.

Cunningham, J. T.—"Spermatogenesis in Myxine glutinosa," Quart. Journ. Micr. Sci., xxxiii, 169; Zool. Anzeiger, 1891, 22.

Driesch, Dr. Hans.—"Tektonische Studien an Hydroidpolypen," parts i and ii, Jenaische Zeitschrift, xxiv, 189 and 657 (N.F. xvii); part iii, Jenaische Zeitschrift, xxv, 467 (N.F. xviii).

Garstang, W.—"Note on a New and Primitive Type of Compound Ascidian," Ann. Mag. Nat. Hist., 1891, 265, and Zoologischer Anzeiger, 1891, 22 (preliminary note).

Greenwood, Miss M.—"On the Action of Nicotine on Certain Invertebrates," Journ. Physiology, xi (suppl.).

Harmer, S. F.—"On the British Species of Crisia," Quart. Journ. Micr. Sci., xxxii, 127.

Harmer, S. F.—"On the Origin of the Embryos in the Ovicells of Cyclostomatous Polyzoa," Proc. Camb. Phil. Soc., vii.

Harmer, S. F.—"On the Regeneration of Lost Parts in the Polyzoa," Rep. Brit. Ass., 1890.

Johnson, Prof. T.—"Observations on Phæozoosporeæ," Ann. Bot., v.

Johnson, Prof. T.—"The Callosities of Nitophyllum versicolor," Journ. Roy. Dublin Soc., 1892.

Minchin, E. A.—"Note on a Sieve-like Membrane across the Oscula of a Species of Leucosolenia," Quart. Journ. Micr. Sci., xxxiii, 251.

Ridewood, W. G.—"The Air-Bladder and Ear of British Clupeoid Fishes," Journ. Anat. Phys. (London), xxvi, 26.

Robinson, Miss M.—"On the Nauplius Eye persisting in some Decapoda," Quart. Journ. Micr. Sci., xxxiii, 283.

Weldon, Prof. W. F. R., F.R.S.—"The Renal Organs of Certain Decapod Crustacea," Quart. Journ. Micr. Sci., xxxii, 279.

Weldon, Prof. W. F. R., F.R.S.—"The Formation of the Germ-layers in Crangon vulgaris," Quart. Journ. Micr. Sci., xxxiii, 343.

An important prosecution, the first of its kind, we believe, to have been taken under the Sea Fisheries Regulation Act, 1888, was instituted in March last by the Kent and Essex Fishery Committee

of the County Council against the East and West India Dock Company, for depositing sludge dredged from the docks on ground alleged to be good trawling ground for flat-fish and shrimps, contrary to the Bye-laws of the Committee. The defendants were fined £10 and costs, and an application to the magistrates to state a case on the question of jurisdiction was granted.—G. H. F.

A TRAWL-NET which seems likely to prove useful to yachts, and to any vessels for which a beam-trawl is prohibited by its size and weight, has been brought to my notice by the patentee, Mr. John Thurlow, of 26, Cleves Road, Eastham. It consists essentially of the ordinary otter-trawl with the addition of a third otter-board, set so as to skid upwards and to keep the gape of the net open. It thus disposes of one of the objections to the ordinary otter-trawl, that the upper edge of the net being immediately over the foot-rope, fish can escape upwards (cf. Holdsworth, Deep-sea Fishing and Fishing Boats, p. 372), a possibility here prevented by the third otter-board coming as far forward as does a trawl-beam over the foot-rope. The inventor will supply specimens and models of the net if desired.—G. H. F.

Gadus esmarkii (Nilss.).—I took a female, about three parts ripe, from the stomach of a halibut, trawled on or about the 31st January on the south-western flat, a ground which lies due west of the coast of Northumberland, between long. 1° and 3°, but chiefly to the westward of long. 2° 30′, and thus within the British area as defined by Canon Norman (Ann. and Mag. Nat. Hist., 1889, p. 345). The soundings are from 30 to 50 fathoms cable. Another halibut contained, on the same occasion, the remains of two small gadi, which were probably of the same species. The Norway pout has been shown by Dr. Günther (Deep-water Fishes, P. R. S. E., vol. xv, No. 127, p. 212) to be common enough in certain localities on the west coast of Scotland, and I have shown that it is by no means rare on the west of Ireland (*vide* Scien. Proc., R. D. S., 1892, pt. 4). Its range must now be extended to the east coast of England.—E. W. L. H.

Phycis blennioides (Brünn).—Two fork-beards were received during March from the ground to the north-west of the Great Fisher Bank, lat. 57° 40′ N., long. 2° 20′ E., 40 fathoms, and lat. 57° 45′ N., 46 fathoms. The first was a female with ovaries but little advanced, containing slightly opaque ova, the largest ·15 mm. in diameter. The other specimen had had its viscera removed by its captor, with a view to its better preservation. The fork-beard seems to be

rather rare on the North Sea grounds, since the Grimsby fishermen are quite unacquainted with it. The specimens I have alluded to were regarded as hybrids between a tusk and a haddock.—E. W. L. H.

A specimen $18\frac{1}{4}$ inches in length has also been received at Plymouth. It was taken on a whiting hook, 5 miles from shore on hard ground.—W. L. C.

Sebastes norvegicus (Ascau).—The Norway "haddock" seems to be rather common in the deep water about the Fisher Bank, but has no vernacular name amongst the Grimsby fishermen.

Crystallogobius Nilssonii (Düb. and Kor.).—Mr. Cunningham's remarks on the distribution of this form, in the last number of the Journal, will be remembered. I have recently been able to show that it is very generally distributed, at depths from 10 to 35 fathoms, along the west coast of Ireland (loc. cit., p. 284), and am now able to record it from the "Head" ground, 15 to 20 miles E.S.E. of Flamborough Head, 29 fathoms, having trawled a perfect specimen there on the 19th March. I have seen fragments, which I suppose to belong to the same species, adhering to the nets of boats returning from other grounds, and suspect that the use of suitable nets would show that it is pretty common. The fishermen told me that they considered such fish as my specimen to be young haddocks, but the resemblance to a young herring or sprat is more obvious.

E. W. L. H.

Arnoglossus laterna (Walb).—I received a specimen from 35 miles off Flamborough Head, 33 fathoms, on the 20th February. The species does not seem to have been recorded from the east coast of England, though it occurs in Norwegian waters, and has been taken off the coast of Banffshire.—E. W. L. H.

Raia alba (Lacép.).—On the 29th of February, when looking over a very large "take" of skates landed on the Plymouth Barbican, I was fortunate enough to notice a fair-sized specimen of this our largest, though seldom observed, British species. It measured 6 feet $2\frac{1}{2}$ inches extreme length, and 5 feet 1 inch across the wings. The colour in the dorsal surface was a dull brownish grey. The ventral surface was a dead white on every part except where the extreme margin of the fins showed a translucent red. The specimen was a female, but had the characteristic sharp teeth seen in both sexes of this species. On the under side, from the level of the mouth to the tip of the snout, there was a thick covering of spines, and fully half-

way from the tip of the snout to the outer angle of the wings ran a band of spines embedded in the flesh, the points projecting inwards as do the spines seen on the dorsal surfaces of the wings of male skates generally. This band was about 2 inches broad. The body was extremely thick, being to the grey skate what the body of a halibut is to that of a turbot. The tail was not long in proportion to the body, and was provided with spines in a somewhat unusual manner. Starting from the body, three rows were visible, but the outer one rapidly developed into a band similar to, though narrower than, that described for the anterior margin of the wings. These spines were, however, not embedded in the flesh of the tail. The skin of the back was not so smooth as in *R. batis*, nor so rough and shagreen-like as in *R. macrorhynchus*.

Raia alba, the white skate, is mentioned in Couch under the names Burton skate and Bordered ray. The latter name arises on account of the appearance of the young.

About ten days after noticing the large example, the fisherman of the Association brought in a young specimen. The name bordered ray would be appropriate in this case. The spines are again present between the region of the mouth and the snout and down the anterior margin of the wings, but on the tail are three rows of large spines only, a central row of fifteen, and on each side a marginal row of eleven, much curved and pointing directly backwards. The colour of the back is a light olive-brown, of the under side white centrally, shading through yellow into a broad dirty brown-coloured border. The under surface of the tail is also like the border to the wings. These young bordered rays were said by Thompson to be plentiful in Portland Roads. The adult skate is recorded on the south coast, from Weymouth (Goose), Lyme Regis (Jarrell), off Cornwall and Plymouth (Day). It appears only to frequent deep water, but must deposit its eggs in shallower water, the young being found in this situation.—W. L. C.

Young Lobsters.—On the 30th March I received from Mr. Dunn, of Mevagissey, an associate member of the Association, three lobsters of a very interesting size. They were all alive, and measured as follows :—9·6 cm., a male ; 11·5 cm., a female ; 13·1 cm., a female, the measurements in each case being from the tip of the rostrum to the end of the telson.

I am not aware that anyone has ever recorded the capture of a lobster of adult form so small as 9·6 cm., or roughly $3\frac{3}{4}$ inches long.—W. L. C.

A New British Nemertine.—On March 22nd a nemertine worm was

trawled off Stoke Point in about 25 fathoms, which corresponds to the description given by Hubrecht* of *Carinella polymorpha.*

Hubrecht's description is as follows:—"Differing from the foregoing species (*C. annulata*) by the form of the head, which is still wider and more hammer-shaped, as well as by colour, which is always a uniform reddish or orange-brown."

This species is synonymous with *Valencinia splendida* of de Quatrefages, and *Tubulanus polymorpha* of Renier. It has never, I believe, been found before on the British coasts. Its geographical extension, as given by Joubin,† is Banyuls, Roscoff, Bréhat (de Quatrefages), Naples (Hubrecht), Adriatic (Dewoletzky), ocean and Mediterranean (Vaillant). McIntosh, in his monograph, describes a worm from the island of Herm, which is perhaps identical with this species, but which he regards as a variety of *Carinella annulata.*

Neither Hubrecht nor Joubin mentions the existence of extremely faint lines, which are quite similar in position to those of *C. annulata,* except that the median ventral line seems absent. They are so faint that it is with great difficulty that they can be seen at all, and they in no wise interfere with the uniformity of the orange-brown colour, which seems, except on very minute inspection, to be uninterrupted. In the *Carinella* from the island of Herm, McIntosh mentions the existence of a pale lateral line on each side, and faint traces of transverse bars on the dorsum.—T. H. R.

Culture of Sea Fish.—From the Annual Report of the Newfoundland Fisheries Commission for the year 1891, presented to the Legislature March, 1892, the following interesting extracts are taken. Speaking of the Dildo hatchery, the Report says:—"By July 25th there were 616 codfish in the wells. The total number of ova stripped from these fish was 78,950,000. Of these, 39,650,000 were rejected, and 39,650,000 were hatched and planted in a healthy condition. This gave the satisfactory yield of 50·2 per cent. During the month of December an important improvement, which had been in contemplation from the first, was carried out at Dildo—namely, the construction of a salt-water pond, in which the codfish will be placed to spawn in the natural way, instead of undergoing the process of stripping. This pond is 47 feet in length and 23 in breadth, and is most substantially built of stone and Portland cement. There is a specially constructed collector and other apparatus to gather up the ova as they are extruded from the fish, and fertilized;

* Hubrecht, *The Genera of European Nemerteans,* Notes from the Leyden Museum, No. 4, vol. i.

† Joubin, *Sur les Turbellaires des Côtes de France,* Arch. Zool. Exp., 2 ser., vol. viii.

and they are then conveyed to the hatchery. Mr. Neilsen anticipates that he will be able to hatch 70 to 90 per cent. of the ova, instead of 50 per cent. as at present, by this improved method. Such results have been recently attained at Flödevig hatchery in Norway, where, partly through Mr. Neilsen's recommendation, it was adopted two years ago. . . . The total number of lobster ova obtained was 18,505,600 ; and of these 10,274,300 were hatched and planted." This is the most extensive hatching of sea fish yet accomplished.—W. L. C.

Marine Biological Association of the United Kingdom.

Report of the Council, 1891-92.

The Council.

Since the last Annual Meeting the Council has met ten times for the conduct of the business of the Association.

The vacancies caused by the retirement of E. W. H. Holdsworth, Esq., and of G. J. Romanes, Esq., F.R.S., were filled in July by the election of Sir Albert Rollit, M.P., and of S. J. Hickson, Esq., D.Sc. No changes have occurred during the year among the Officers.

The Council has to acknowledge the courtesy of the Royal Society in granting the use of its rooms for the several meetings of the Association.

The Laboratory.

The buildings and machinery at Plymouth have been maintained in a satisfactory condition. No serious repairs have been found necessary.

Boats.

The Council is unfortunately unable to report satisfactorily of the condition of the Association's boats. The cost of constant repair to the old steam-launch "Firefly" has become so large, and her working is so uncertain, that it has become an imperative necessity to replace her. The cost of the annual maintenance of such a steamboat as the Association needs is at present beyond its power, namely, a boat in which longer expeditions may be made than has hitherto been practicable.

The Library.

No important bequest has accrued to the Library this year such as was chronicled in the last Report. It is, however, increasing gradually, chiefly in the direction of periodicals. To those naturalists who have presented separate copies of their works the Council renders the thanks of the Association.

The Staff.

At the last Annual Meeting it was announced that Mr. J. P. Thomasson had generously offered £250 for the expenses to be incurred in carrying out observations in the North Sea bearing on the proposed closure of certain fishing grounds by International convention. The Council was fortunate enough to secure for the investigation the services of Mr. E. W. L. Holt, who commenced work in January last.

Mr. W. Garstang, formerly Assistant to the Director, has been appointed a Naturalist on the Staff, and entered on his office on May 30th. His chief duties will be to superintend the collection and supply of material to workers both in the Laboratory and elsewhere.

Mr. F. Hughes, who was appointed temporarily to carry out investigations on the question of artificial bait, has concluded his year of office.

Scientific Investigations.

Mr. Cunningham has been chiefly occupied during the past year in continuing his valuable observations and experiments on young food-fish with reference to their habitat, rate of growth, and attainment of sexual maturity. His results will be found in detail in the last two numbers of the Journal, and it will suffice to mention here that some of the flat-fish which he has reared from about a half-inch in length are now nine inches long, and have reached sexual maturity. Direct observation of this kind is of the utmost value, as supplementing the information derived from fish under natural conditions.

The daily meteorological observations have been continued by Mr. Dickson.

Mr. Holt has only been at work for six months, but his results promise to be of extreme interest. Their scope may be gathered from his notes and from the Director's Report in the last number of the Journal. The Marine Fisheries Society of Grimsby has generously placed its aquarium at Cleethorpes at his disposal, and the Council has undertaken in return to pay half of the caretaker's salary. The Council begs to tender the thanks of the Association to the Society for its assistance in this matter.

It was announced in the last Annual Report that a special drift net was being constructed for the purpose of ascertaining whether anchovies could be procured on the south coast in sufficient numbers to make an anchovy fishery a commercial success. The weather last autumn was most unfavourable for the enterprise: the fish taken by our nets, on the few occasions when they could be used, were very large, and but few in number, although in some places at the same

time the herring boats struck large shoals of anchovies. Enough, however, was achieved to justify the repetition of the experiments this year with a reasonable hope of success.

The usual experiments on hatching and rearing fish have been continued.

Eleven naturalists have occupied tables in the Laboratory during the past year for the prosecution of their special researches:

Miss F. Buchanan, B.Sc., University College, London (Anatomy of *Polychæta*).

Mr. F. W. Gamble, B.Sc., Owens College, Manchester (Eyes of *Mollusca*).

Mr. W. Garstang, M.A., Owens College, Manchester (*Tunicata*).

Mr. E. de Hamel, Birmingham (General Zoology).

Mr. S. J. Hickson, M.A., D.Sc., Downing College, Cambridge (*Alcyonium*).

Mr. W. J. Hughes, Birmingham (General Zoology).

Miss M. Robinson, University College, London (Nauplius eye of *Palæmon*).

Mr. T. H. Riches, M.A., Caius College, Cambridge (*Hormiphora* and *Paguridæ*).

Mr. A. H. Stewart, B.A., New College, Oxford (*Holothuroidea*).

Prof. W. F. R. Weldon, M.A., F.R.S., University College, London (Development of *Crangon*).

Mr. A. Willey, B.Sc., University College, London (Development of *Tunicata*).

It is satisfactory to note that, in addition to those which have appeared in the Journal, seventeen original papers have been published elsewhere in the course of the last two years, on work done in the Laboratory.

Finance.

The receipts of the past year include the annual grants from H.M. Treasury (£1,000) and the Fishmongers' Company (£200); the annual subscriptions and composition fees have realised £219, the interest on investments £35, the rent of tables £50, the sale of specimens £87, the charge for admission to the aquarium £84.

The statement of receipts and payments for the year is annexed.

The List of the Officers and Council proposed by the Council for the year 1892–93 is as follows:

PRESIDENT.

Prof. E. Ray Lankester, LL.D., F.R.S.

VICE-PRESIDENTS.

The Duke of Argyll, K.G., F.R.S.
The Duke of Sutherland, K.G.
The Duke of Abercorn, C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
Lord Walsingham, F.R.S.
Lord Revelstoke.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
Prof. G. J. Allman, F.R.S.
Sir Edward Birkbeck, Bart., M.P.
Sir Wm. Flower, K.C.B., F.R.S.
Sir John Lubbock, Bart., M.P., F.R.S.
Prof. Alfred Newton, F.R.S.
Sir Henry Thompson.
Rev. Canon Norman, D.C.L., F.R.S.
Captain Wharton, R.N., F.R.S.
J. P. Thomasson, Esq.

COUNCIL.

Elected Members.

Prof. F. Jeffrey Bell, F.Z.S.
Frank Crisp, Esq., V.P. and Treas. Linn. Soc.
W. T. Thiselton Dyer, Esq., C.M.G., C.I.E., F.R.S.
Sir John Evans, K.C.B., D.C.L., Treas. R.S.
Prof. J. C. Ewart, M.D.
A. C. L. G. Günther, Esq., F.R.S.
Prof. A. C. Haddon, M.A.
S. J. Hickson, Esq., M.A., D.Sc.
E. B. Poulton, Esq., F.R.S.
Sir Albert Rollit, M.P.
P. L. Sclater, Esq., F.R.S., Sec. Z.S.
Adam Sedgwick, Esq., F.R.S.
Prof. Charles Stewart, P.L.S.
Prof. W. F. R. Weldon, F.R.S.

Hon. Treasurer.
E. L. Beckwith, Esq.

Hon. Secretary.
G. Herbert Fowler, Esq., B.A., Ph.D.

Dr. *Statement of Receipts and Payments for the Year ending* 31*st May*, 1892. Cr.

Receipts.	£	s.	d.	£	s.	d.
To Balance from last year, made up as follows:						
Special Fund, Bait Investigation	387	9	9			
„ Steam Launch...............	90	4	0			
	477	13	9			
Less Deficit on General Account	267	17	0			
	209	16	9			
Add old outstanding written off	58	19	0			
				268	15	9
To H. M. Treasury				1000	0	0
„ Fishmongers' Company				200	0	0
„ Donation, J. P. Thomasson, Esq., for North Sea Investigation				250	0	0
„ Annual Subscriptions				154	7	0
„ Composition Fees and Donations				65	10	6
„ Rent of Tables £50 6 0						
„ Sale of Specimens 87 17 3						
„ Sale of Journal..................... 12 0 3						
	150	3	6			
„ Sale of Monograph on the Sole	17	5	0			
„ Admission to Tank Room	84	6	4			
„ Interest on Investment	35	2	0			
				286	16	10
				£2225	10	1

Examined and found correct.

Stephen E. Spring Rice,
Edwin Waterhouse,
W. F. R. Weldon,
F. Jeffery Bell,
} *Auditors.*

16*th June*, 1892.

Payments.	£	s.	d.	£	s.	d.
By Salaries and Wages:						
Director	200	0	0			
„ Allowance for Assistant.........	60	0	0			
Mr. J. T. Cunningham	250	0	0			
Mr. E. W. L. Holt, North Sea Investigation	100	0	0			
Mr. F. Hughes, Bait Investigation	90	0	0			
Wages, Salaries of Assistants, &c.	336	2	3			
				1036	2	3
By Stationery, Office Printing, Postage, &c. ...				154	4	9
„ Printing and Illustrating Journal............				157	7	6
„ Gas, Water, Coal, Oil, &c.	134	18	7			
„ Stocking Tanks, Feeding, &c.	84	8	3			
„ Glass, Chemicals, Apparatus, &c. £147 10 0						
Less Sales 16 12 1						
	130	17	11			
„ Printing and Sale of Monograph on the Sole	1	3	0			
„ Maintenance and General Repairs of Buildings and Boats, including £62 10*s.* purchase of special Anchovy Nets............	201	17	4			
„ Rates and Taxes	31	6	5			
„ Boat Hire	90	17	0			
„ Travelling..	43	16	9			
„ Library	25	2	8			
„ North Sea Investigation.......................	26	11	2			
				770	19	1
„ Balance forward, being Cash in hand, 31st May, 1892, less outstandings, as follows:						
Special Fund, Bait Investigation	297	9	9			
„ Steam Launch, carried to credit of "General Account" by consent of Subscribers	0	0	0			
	297	9	9			
Less Deficit on General Account	190	13	3			
				106	16	6
				£2225	10	1

Investment held 31st May, 1892:
£900 Forth Bridge Railway 4% Debenture Stock at 125...£1125 0 0

Director's Report.

The past summer has been a busy one at Plymouth, and the steady continuance of magnificent weather has made shore-collecting, as well as dredging and tow-netting from the boats, possible at all points in the neighbourhood. The fine weather, as compared to the weather of last summer, seems, moreover, to have had a distinct influence on the pelagic fauna of the Channel. There has been towards the end of the summer a continuance of unusually interesting surface forms, and at the same time almost a total absence of some of the creatures usually found in abundance. For instance, Aurelia has for some unaccountable reason not been found in the Sound this summer, although I have heard of its occurrence in usual numbers in the Solent. Last summer brought innumerable millions of Noctiluca, so that the sea for miles showed orange-red tracks through the dense crowding of these infusorians. This summer has produced practically none.

I particularly note the absence of Aurelia, since it is a form used as a type in teaching, and therefore often ordered from us. It will be impossible to supply Aurelia through the coming winter.

The most important animals captured during the summer are mentioned by one or other of the Staff in the form of special notes, and need, therefore, not be enlarged upon here.

Several gentlemen have taken advantage of the Laboratory to carry on research.

T. H. Riches, Esq., as a Founder of the Association, has continued his studies in Nemertines.

The British Association for the Advancement of Science nominated three gentlemen, viz.—

Edgar Allen, Esq., from the Zoological Laboratory of University College, London, for six weeks.

Gregg Wilson, Esq., Zoological Laboratory, University of Edinburgh, for one month.

F. W. Gamble, Esq., Berkeley Fellow, Owens College, Manchester, for two months.

Mr. Allen worked at the development of Palæmonetes, the fresh-water shrimp.

Mr. Wilson experimented upon the senses of fish, very largely going over the ground covered by Bateson.

Mr. Gamble made a systematic collection and examination of the Turbellaria of the district.

In addition to these gentlemen there were—

R. T. Günther, Esq., from the Anatomical Department, Oxford, working at pigmentation in Cephalopods; and

E. J. Bles, Esq., of Owens College, Manchester, working at a systematic investigation of the "Plankton" of the western portion of the English Channel.

Two alterations have taken place in the Staff of the Laboratory. *Mr. Dickson*, formerly my assistant, who also acted as Physicist, has resigned; and *Mr. Garstang*, previously connected with the Laboratory, has commenced his work:—his appointment having been mentioned in my last Report. I have given into his charge the specimen trade and control of the movements of the steam launch. The arrangement, I find, works well. It is necessary, if the prompt output of well-preserved specimens is to be kept up, that some one person should devote special attention to this branch; and it is hoped, as stated in a previous Report, that the specimen preservation may become more and more perfect under this new *régime*.

With Mr. Dickson's departure the meteorological work has been suspended.

With regard to the Laboratory buildings, little need be said. Slight alterations become necessary from time to time, either for the purpose of improving the general efficiency, or in order that some special investigation may be accomplished with greater ease; the water or gas supply may be rearranged, extra storage room required, or some special apparatus constructed: for instance, five young Mississippi alligators were purchased from a naturalist-sailor home from Florida, and a special hot-water circulation had to be fitted for their benefit. It was thought possible to run the gas engines used in pumping and circulating the sea water with a less consumption of gas, and experiments were tried as to the balancing of speed and power. The result is that now much less gas is consumed, although the circulation is quite efficient.

From the varied nature of the work carried on, such arrangements are expected, but concerning large and important alterations I have nothing to report. A constant watch is kept on all parts of the building, and the establishment maintained in good order, rather than allowed to decline till extensive repairs become necessary. With a comparatively new building this is a matter of no great difficulty;

with the launch, on the other hand, the task is a most disheartening one, being a literal example of the putting of a new piece of cloth on an old garment so that the rent is made worse.

A decided step must shortly be taken to obviate the very great inconvenience caused by the unworthiness and utter collapse of both the engines and hull.

The launch has now served for three years, and was a decidedly old boat when purchased. It is true that she has always been inexpensive in her consumption of coal and water, but of late her extremely inconvenient habit of breaking down has developed itself rapidly, so that the bills for her repair are becoming alarming. It is with a feeling of humility I say it, but she has sometimes broken down as often as three times in one week. It is necessary to work her at a still further reduction of pressure, and she is, moreover, a source of decided danger to those on board. But for the favour of the elements we could have done little sea work during the past summer. There is a certain sum of money—inadequate, no doubt, but still a nucleus—forming what is termed the Boat Fund. In the hope that through the circulation of the Journal, members and others may care to read this report, I venture to write plainly with regard to this our most urgent necessity. Whether or not the Association buys a large sailing trawler for fishery investigations, a new launch with which to procure specimens in this locality is imperative.

The Library continues to increase. An exchange of periodicals has just been arranged with the Director of the new German Station on Heligoland, and by the kindness of many authors a constant influx of papers occurs from all parts of the civilised world.

Constant additions are also being made to the aquarium. At present the tanks show, in addition to ordinary examples of the cod family, dog-fishes, crabs, and flounders, a fine collection of wrasses, some extremely large congers, a red mullet, schools of bass, pipe-fishes, turbots, soles, and other flat-fishes, and a large variety of anemones. The attendance of visitors keeps up, and when some special animals are on view, and an advertisement has been inserted in the local papers, the money taken at the door often becomes considerable. The aquarium is now becoming recognised as one of the sights of Plymouth.

Mr. Cunningham has lately been devoting most of his time to a study of the coloration of fishes' skins, and to a continuation of his work on the rate of growth of food-fishes.

As an addition to the range of his work in connection with the latter subject, a large amount of material has been supplied to him by Mr. Holt from fishes collected at Grimsby and in the deeper

parts of the North Sea. In this number will be found a paper by Mr. Cunningham dealing with this material, as compared with the specimens collected at Plymouth. The study of pigmentation in fishes is the outcome of the interesting experiments instituted two years ago, and still in progress—I refer to the cultivation of pigment on the under side of flat-fishes by the action of reflected light.

In my last Report I gave a sketch of the work in the North Sea at present being carried on by Mr. Holt. Much valuable information has been collected as to the sizes at which the various food-fishes spawn for the first time; and it is found that just as the fish of the North Sea are, as a rule, larger than those caught on the south coast, so the spawning periods occur when the fish are of larger size. If legislation as to trawling in the North Sea is to be contemplated, and a restriction put upon fishermen as to the sizes below which it is illegal to capture or sell fish—this legislation being international in character,—then the only rational point of view from which to regard the question is surely the biological one. If we follow the example of a maritime power on the other side of the North Sea, and make the restrictive sizes so small that the fish have never had a chance to spawn before they are captured, then, it appears to me, we do good only to a very limited extent. We do not help in any way to maintain the upkeep of the breeding stock, and therefore do not in the slightest degree touch the question of increased food supply. We only aid the fisherman to some slight extent by keeping very small fish out of the market. We make him sell his small immature sole for a shilling instead of his minute sole for a sixpence. We do not in any way prevent this improvident person, who is, of course, working for a living against keen competition, from drawing upon his stock in trade until he has no more to sell; and since the fisherman represents the manufacturer, so far as the consumer is concerned, the process sooner or later works itself out till the fisherman disappears, and the consumer finds that he can no longer buy his sole.

A very serious difficulty which presents itself in connection with the North Sea trawling industry is, that to prevent the capture of fish till after they have spawned once, would mean the temporary elimination from the markets of a very considerable quantity of certain species, and a corresponding reduction in the incomes of the fishermen or fishing companies, who can already ill afford to submit to such a process.

Mr. Holt, in his "Remedial Measures" at the end of his paper on *The Destruction of Immature Fish in the North Sea*, deals with this important question, and I would call the attention of those interested in the North Sea investigations to this section.

Taking up the advisability of preventing the sale or having possession of flat-fish under a certain size, he advocates the adoption of the biological standard (that of sexual maturity) for turbot, brill, and sole; but is able from a careful study of the eastern grounds on which the small fishes are mostly found, and the sizes above which the fishes in those localities do not appear to be captured, to suggest a way of escape from the difficulty which has ever been present since it was found that, in the North Sea, plaice were of good marketable size before they spawned.

Speaking of the Fishery Conference of last February, he says that if the "limit of eleven inches for plaice were enforced, there would still be enough saleable fish left to make the grounds worth visiting; whereas if it were raised to fifteen or even fourteen inches, the grounds would assuredly be left alone."

To prevent the capture of plaice under eighteen inches (the size at which this species is found to spawn in the North Sea) would mean the practical prohibition of the fishery. This proposition of Mr. Holt's seems to me, therefore, to be of very decided value, since, while sticking to the same system, it compromises the one great practical difficulty.

The Sea Fishery District Committee of Cornwall, like the Committee for Lancashire, has recently been considering a measure for the limitation of the sizes under which fish may be taken in their territorial waters. It is a fortunate circumstance that in this case, and on the south-west coast generally, flat-fishes when spawning for the first time are of a very much smaller size than is the case in the North Sea, because the average sizes of the fish taken are very much less. The whole rate of growth appears to be slower.

At the British Association meetings held this year in Edinburgh, a discussion on the Application of Biological Science to Fisheries was arranged for. Mr. Holt, being the member of the staff engaged in our most important fishery investigation, was sent to take part in the proceedings.

In the course of the discussion the possibility of concentrating scientific power from various important points of the United Kingdom, and the great benefit which would be derived from one central and controlling department of the Government, was commented upon. England especially is in want of some organising body, by which the scientific knowledge already acquired concerning her fisheries may be applied for the protection and improvement of the industry. The fisheries of England are surely not less important than those of Scotland or Ireland, and should not be left to take care of themselves. The outcry on every side that our fisheries are being depleted ought to make us investigate the cause and apply the remedy. Unofficial

bodies, who have to rely on private support or Government subsidy, should not be expected to make fishery investigations of national importance on the chance that the legislative machinery of the Government can be brought into action. England has her Worshipful Company of Fishmongers, her National Sea Fisheries Protection Association, and the investigating body for which I have the honour to act as Director. Fishery Conferences are held and resolutions passed; but the misfortune is that these resolutions are not passed by a body with power to legislate, nor can they be placed before a body whose special function it is to investigate their importance on behalf of the Government.

Yet we must continue our investigations and acquire more and more knowledge, so that if at some future period the suggestion thrown out at the British Association meetings be realised, we may be found ready at once to supply the scientific data necessary for the production of thoroughly sound fishery legislation.

W. L. Calderwood.

A Contribution to our Knowledge of the Ovary and Intra-ovarian Egg in Teleosteans.

By

W. L. Calderwood,
Director of the Laboratory of the Marine Biological Association.

With Plates XI and XII.

THE reproductive organs of Teleosteans have been studied by many writers. All observations, however, appear to be either on the organ as seen at only one season of the year, or on the early maturation of the ovum and development of the embryo. I do not in this paper concern myself with the primitive development of the ovary, or the subsequent growth of the permanent ova from the primitive ova or sexual cells of the embryo (1). My attention is rather centred on the adult and mature organ in its various conditions of sexual activity or repose.

I have preserved and sectioned a series of ripening ovaries, and have also turned my attention to the spent organ, and the manner in which it again reaches the condition of what is sometimes known as sexual inactivity; in this way completing what I may call the adult ovarian cycle.

I have examined the ovaries of the following species:—*Pleuronectes limanda, Trigla lyra, Trigla limanda, Labrax lupus, Lophius piscatorius, Clupea finta, Ammodytes tobianes, Gadus æglifinus, Solea vulgaris, Conger vulgaris,* and *Merluccius vulgaris.*

My most complete series of sections are of the ovaries of the common dab (*Pleuronectes limanda*) and hake (*Merluccius vulgaris*), forms readily procurable at Plymouth. The main results of this paper are, therefore, drawn from the examination of these species, sections from the ovaries of the others being used for comparison.

Since the ovary is modified to suit the requirements of the

ova, and affected according as the principal ova are ripe or unripe, it will be convenient to consider the ova first.

THE OVA.—*General.*

All writers on the intra-ovarian condition observe large and small eggs in ovaries of fishes which are in any way approaching ripeness.

Scharff (2) treats in one chapter on the small ova, in another on the large.

My observations incline me to consider that three conditions must be noticed for fishes, as has been done in the case of batrachians, since it seems more than probable that, in all ripening ovaries, ova for three consecutive spawning periods are present. I therefore propose to treat of the ova under the names of great, small, and minute.

The condition is very well seen in sections from the unripe ovary of a haddock, where the *small* ova are about the size of the nuclei of the *great*, and the *minute* are gathered together in clusters, and are individually by no means so large as the nuclei of the small ova.

So far as I can ascertain, the organ in its flaccid or spent condition has not been previously investigated. Very considerable difficulty has been experienced in obtaining good preservations of spent ovaries, the semi-fluid contents and general disintegration of parts rendering very great care necessary. By removing the organ *in situ* into the fixing reagents it has, however, been possible to obtain sections showing what I believe to be accurate representations of the organ in this condition.

Scharff, in his paper already referred to (2), described the smallest ova in the haddock (*Gadus æglifinus*), and what he terms the next stage in the gurnard (*Trigla gurnardus*). These two stages, so far as I can determine, are not stages in the development of one season's eggs, but represent ova which will be extruded at two distinct spawning periods. The larger eggs of his second stage represent, in fact, the formation of great ova at the completion of a spawning season.

The material collected for his excellent paper was preserved in the summer, the only time when this condition can be seen.

I am also led to this conclusion by his description of the eggs themselves.

They show a circular division of the protoplasm into two distinct zones, the inner of the two surrounding the nucleus being more granular, and in section much more darkly stained than the outer; while the nucleus has its membrane, chromatic substance,

and nucleoli. When the ova are in this condition the ovary is in process of being reconstructed. With the process of spawning the lamellæ have been ruptured and the stroma scattered. With the inward growth of the supporting tissue which will be treated of later, the eggs which are at a future period to follow those which have already been extruded are being collected into new lamellæ. The flaccid and utterly empty condition of the ovary, as seen in the sections of the spent organ, has to be overcome. By means of a fairly complete series of slides I have been able to follow through this stage, and conclude that this condition of protoplasmic separation in the ovum has a significance not so much connected with the development of the ovum itself as with the building up of the trabeculæ of the ovary.

A circular separation of the protoplasm in the egg of fishes has been noticed by Eimer (3) as far back as 1872, and a similar arrangement has been commented upon in reptiles, molluscs, and insects by other authors. To account for it various suggestions have been made. The dark ring must either take its peculiar property from some outside tissue, or stain darkly because it has received matter from the nucleus. Will, in treating of Orthoptera, (4) describes the disappearance of the nuclear membrane and the migration of nucleoli to the surface of the ovum, forming in this way a follicular epithelium. Scharff also (loc. cit.) notices the presence of a few nucleoli outside the nuclear membrane of *Gadus virens*, and assigns the peculiar property of this darkly stained layer to the presence of nuclear substance.

The clear protoplasmic portion seems to have attracted less attention, and to be generally considered as the normal unchanged protoplasm of the egg. So far as I know, the ultimate history of the clear and dark layers has not been traced to its issue.

In sections treated in the usual way the dark portion often becomes rather opaque for good observation, the staining having a distinct resemblance to that seen in the colouring of nucleoli. Nevertheless at this particular stage I have not, in the common dab, been able to detect the presence of nucleoli outside the nuclear membrane, although those bodies have been sufficiently apparent in this position at other stages. Scharff says that he saw these nucleoli occasionally in the dark layer, but never, except in the case of *Hippoglossoides*, at the surface of the egg. The explanation may probably be that in different species the nucleoli are given off at different times, and that in the case of the common dab this process takes place previous to the differentiation of the areas. I find that the light protoplasm soon splits off from the dark.

Fig. 1 shows this process. The egg seems to increase rapidly in

circumference, owing to the extension of the light protoplasm alone, while the dark protoplasm and nucleus remain as before. A condition is presently reached where this extension causes the light to separate from the dark, so that a cavity is formed around the dark centre with its contained nucleus, *i. e.* around what must now be considered as a complete ovum in itself. The light protoplasm then appears to diminish in extent until only a margin is left inside of what was the old investing membrane.

The cast-off membranes of neighbouring eggs coming in contact with each other, and the light protoplasm being almost completely absorbed, the appearance becomes that of trabeculæ. The contained spaces are occupied by the ova, and the interstices become filled up by fresh ova of a small size, formed from epithelial cells in a manner to be described at a later stage.

I. *The Great Ova, or those which are to be extruded at the first spawning period.*

In the ovary of a common dab which is approaching ripeness (fig. 2) the large ova are well marked. The zona radiata has thickened, and the protoplasm of the egg shows a distinctly reticulated structure. The nuclear membrane has disappeared, the nucleus now appearing as a clear area, either surrounded by or scattered over with the numerous nucleoli, occupying an eccentric position in the ovum.

The nucleoli are much more circular in shape than is the case in eggs of an earlier stage, and when they are arranged round the periphery of the clear area there are numerous very minute bodies of exactly the same appearance to be found in the area itself. These minute bodies must also be considered as nucleoli, for from an examination with a very high power I find that they are budded off from the large nucleoli at the margin of the clear area, and then travel inwards towards the centre. Fig. 3 is drawn from an ovum in the same section as is represented by fig. 2, and sufficiently represents the appearance indicated. These small bodies, by enlarging, form another condition of the nucleus seen at this stage. The parent nucleoli seem to give off many buds in this way, until, having lost much of their old constitution, they stain feebly, and are difficult to distinguish from the coarser granules of surrounding protoplasm.

There is, therefore, among Teleosteans a more or less distinct congregation of nucleoli in the centre of the degenerating nucleus, similar to that described by Iwakawa (5) in the egg of *Triton* at a different stage. This author concludes that the nucleoli, or, as

he terms them, the "germinal dots," move to the centre and divide up.

I am inclined to think that in the case of Teleosteans the greatest amount of division takes place at the surface of the nucleus, and that many of the parent nucleoli afterwards become absorbed in the encroaching protoplasm. In this case the darkly stained protoplasmic ring spoken of above is in part explained.

The vacuolated condition present in the nucleoli of *Triton* during their division, and also described by O. Hertwig (6) in the egg of *Hæmopsis* and *Rana*, and by V. la Valette St. George (7) in the egg of *Libellula*, is not present; nor is there any concentration of these division products into a mass in the centre of the nucleus. A vesicular condition, however, which might be mistaken for vacuolation, appears, and is described below in the case of the conger.

The surrounding protoplasm continues to encroach on the space of the former nucleus, and the central nucleoli appear to be ultimately enveloped in this condition. They then correspond to the permanent nucleus of the ripe ovum as described by Hertwig in *Toxopneustes*.

In the ovary which is quite unripe, in distinguishing the three generations of eggs, many intermediate stages leading from the one to the other are at the same time noticeable. The largest of the eggs in the common dab of this stage do not measure more than four fifths of a millimetre. The nucleus of these eggs has a distinct membrane, and the nucleoli are arranged in contact with its inner surface, so that in section they appear in a ring inside the membrane—the usual appearance of nucleoli in fish eggs. The ova at this stage do not present so marked a contrast as they do later, the proportions between the sizes being less.

The ovary of the common dab may be found in this unripe condition all through the autumn and winter months; it is, therefore, the condition which has been often noticed. About two months before spawning takes place the great ova, which will be ripe for the first spawning season, show signs of rapid enlargement, and in a comparatively short time assume the appearance seen in fig. 2, already described.

I have made no direct observations on the origin of the micropyle, and will pass over the egg in the ripe extruded condition. It has been noticed (8) on more than one occasion along with the ova of other Pleuronectids (9).

I shall rather take up the consideration of the ovary after the act of spawning. Great ova are then still present in limited numbers. I have counted the number visible in several transverse sections, and find that there are from ten to fifteen seen in each section. It

is well known that in many Teleosteans all the eggs are not shed at once, but are rather got rid of a few at a time, brief intervals occurring between each extrusion. In sections of spent ovaries the first thing which strikes one is that the remaining great ova are in many cases provided with a complete nucleus with its surrounding membrane, and nucleoli arranged round the periphery, just as is seen in the egg before it is ripe.*

The majority of the ova, however, either show the after condition in which the nuclear membrane has vanished and the nucleoli are collected towards the centre, or they are in the condition of having no nuclei at all, and are advanced in the process of disintegration. When in this last condition they present a vacuoled and atrophied appearance, seen in fig. 4, where an ovum with nucleoli still present, although the outer protoplasm of the egg is beginning to show signs of decay, is also seen. The eggs still presenting the nucleated appearance are a few which, in my estimation, have never become quite ripe; and, from the appearance of the ovary before spawning takes place, I am inclined to think that a few must be extruded in this condition. One does, in fact, generally notice that when fertilizing by artificial means a quantity of spawn, there are some which seem impervious to the action of the spermatozoa.

The eggs left in the spent ovary become opaque, and can readily be noticed in the fresh organ on this account. They are present for a considerable time after spawning is over.

The small nucleoli, budded off in the manner already mentioned, eventually appear to become free in the loose débris of the spent organ by the total disintegration of the protoplasm around them. The progressive history of the *nucleoli* can be seen very well in the conger, because these bodies are of specially large size. In studying this form the usual appearance is seen to be granular, but in some instances the granules are arranged in the form of a circle placed eccentrically, as seen in fig. 5. As the egg approaches ripeness, however, I find some interesting appearances. While the nucleus has yet a distinct membrane, and the nucleoli are oval in outline—the long axis being placed in a radial manner—a clear highly refracting band appears across the short axis. This band becomes spherical, and increases in size till the granular substance of the nucleoli is collected only at the two poles. I notice, however, that the inner pole has always more granular matter than the outer. These vesicular bodies have a distinct double contour, and are of a somewhat smoky colour even in stained sections. Their growth is towards the nuclear membrane, and eventually, when this

* In one instance I observed that a large nucleolus was about to give off four small circular nucleoli, showing that the progressive development had not yet ceased.

membrane begins to disappear, they burst through, forcing in each case a small amount of nucleolar substance in front of them—the outer pole of the nucleolus. They then take up a position amongst the surrounding yolk-spheres. The nucleolar portion which is thrown off does not assume any definite shape, but rather becomes loosely interspersed amongst the yolk-spheres. It still stains readily. Unfortunately, up to the present date no observer has been able to obtain the ripe egg of the conger. I am on this account unable to make any definite statement as to what becomes of the vesicles just described. I can only throw out the suggestion that there is probably some connection between these vesicles and the oil-globules. The supposition is based simply on the striking resemblance which the vesicles have to oil-globules, and on the absence of any theory which accounts for the existence of the globules in any other way.

Scharff (loc. cit.) mentions clear vesicles with granular nucleolar contents as being budded off in *Trigla*, but supposes that the vesicles are formed in the nuclear substance itself. The ovum of *Trigla* has a large oil-globule, or it may be two or three small ones (the last case being rare). Should the vesicles described by Scharff prove to be analogous to those I have just described, a still greater probability will be given to my suggestion. Personally I am inclined to think that the vesicles are analogous, although not noticed by Scharff as coming from the nucleoli. I have not met with any other products of the nucleoli, such as the tubular prolongations described by Balbiani (**10**) in *Geophilus*. When the nuclear membrane has disappeared the nucleoli have given off so many of these spheres, and have themselves taken up a position so far back from where the nuclear membrane originally was—partly, no doubt, on account of their outer poles having been carried away—that the space of the nucleus has become small and irregular. Since, as I have already said, it is extremely difficult to procure a ripe conger, I have not in this species been able to follow through the so-called disappearance of the nucleus.

II. *The Small Ova.*

In fig. 4, which has already been referred to, the three classes of ova are distinctly seen.

To study the small ova from their very commencement, one should begin at the point where the *small* ova are for the first time distinguishable from the *minute, i. e.* when the ovary is in a quite unripe condition, a year and a half probably before the small ova will be extruded; but since the small ova show no change till the time when the great ova have to be discharged, the early period may be passed over.

My account of the small ova, therefore, simply becomes one of their transformation into great ova at the time when the latter are extruded.

In the spent ovary, then, where a few great ova still remain, the small ova of the past year are seen to present two distinct appearances ; one that of fig. 4, the normal, and another a much-vacuoled condition, seen in fig. 7. In both I find signs that the ova do at this stage divide. I have chosen figs. 7 and 8 to represent this, both being taken from the same section. There is a considerable amount of variation in the sizes of the eggs of each condition, but from a series of careful measurements I do not distinguish any difference between the average sizes of sufficient importance to be worthy of mention as of significance. It will be noticed from the figures that the non-vacuoled ova have the nucleus with its nucleoli present in the ordinary position, whereas in the vacuoled eggs the nuclear membrane has no nucleoli in connection with its inner surface. I have examined a large number of slides showing ova in this condition, but only on one occasion have I found a slight trace of nucleoli. They appear in the normal position, but are extremely small in size, and have apparently atrophied. In a few eggs, which show what I may perhaps describe as an inclination to become vacuoled, the nuclei are already considerably reduced. I further notice that for the most part the vacuoled eggs lie at the surface of the ovary, the normal or fully nucleated eggs being towards the centre in the vicinity of the germinal epithelium. I am convinced that the vacuoled eggs break up simultaneously with the few remaining great ova. There is probably a double significance of this curious condition. The fact that a limited number of great, and very many small eggs should break up at the same time may go to show that the old eggs are not present in the spent ovary, simply because they could not be extruded, but because they may be useful as pabulum, and that there are a superabundance of small eggs formed from the epithelium at an early stage. It is somewhat difficult to estimate with any degree of accuracy the number of eggs present in an unripe section, although in the case of the riper organ there may be less difficulty. Numbers no doubt vary in different individuals ; but it seems probable that even with the great enlargement of the organ and the filling up of the central cavity in ripening ovaries there is not room enough, after the great eggs are gone, for a sufficient number of new developing minute ova. At this stage, at any rate, the débris of the organ is added to by the breaking up of a certain number of the ova under consideration, and I take it that the products must either be used for the nourishment of the coming stroma, or are gradually got rid of by extrusion. In the normal eggs of this stage

the nucleoli are few in number but large in size. Whenever the nucleoli atrophy and disappear there is no prospect of the egg ever coming to maturity. Without nucleoli it cannot even form its dark ring of protoplasm. It seems to me that under these circumstances I cannot agree with Scharff and Will, who unite in attaching no morphological significance to the nucleoli.

It is true, as the former says, that they are sometimes present and sometimes entirely absent, but I have never found any evidence to show that without nucleoli ova of Teleosts can ripen. I am, in fact, inclined to regard the nucleoli as of the highest importance, the fountain-head of the entire system.

III. *The Minute Ova.*

The only point of interest in studying the minute ova is their origin, since their average condition is one of inactivity.

After spawning, the enveloping membrane of the ovary sends out fibrous prolongations in an irregular manner towards the centre of the organ. These form leading lines of support in the loose arrangement of the ova. As offshoots from these the supports of the lamellæ are formed. In different species the lamellæ run in different ways, *e. g.* longitudinally in Pleuronectids, transversely in Gadidæ, and obliquely in the mackerel. With few exceptions (Murænidæ and Salmonidæ) the inner boundary line of the lamellæ is composed of germinal epithelium.

It has been stated by Brock (**11**) and Kolessnikov (**12**) that each forming ovum is produced from one single epithelial cell. In addition to this the appearances presented in my sections lead me to believe that, in the case of the common dab at any rate, ova are also formed in another manner. I find small nests of cells, collected at intervals, inside the germinal epithelium, and from watching them am satisfied that while perhaps in the majority of instances ova are formed from single cells only, they are also formed from these nests of, it may be, ten or twelve cells. Fig. 9 shows a growing lamella at this stage, where a few of the nests are seen (n). They are quite separate from all other epithelial cells, and shortly begin to show a disposition to coalesce. The outlines of the individual cells disappear, and the mass, beginning to stain deeply, assumes a very dense appearance.

A collection of deeply stained bodies, very similar to the nuclei of the cells or the amalgamated nuclei, then make their appearance, and take up the position of nucleoli in what must now be called the ovum. Meanwhile there are other epithelial cells collecting in all the spaces of the ovary—often showing division. These grow round

the forming ova, and ultimately form the follicle. I find no sign of a central cell in the nest, enlarging at the expense of the others, becoming itself the ovum while the rest form the follicle. These nests of epithelial cells which become ova have a singular resemblance to the nests described by Balfour (loc. cit.) for Elasmobranchs. In his description of the formation of the permanent ova several primitive ova coalesce to form nests, masses, or syncytii. These nests enlarge in size as development proceeds—explained by the probable division of nuclei without a corresponding division of the protoplasmic matrix, so that nuclei become very numerous. Some of the nuclei unite and become the nuclei of permanent ova, and are budded off with their surrounding protoplasm, which is of small amount; others again break up, and are used as pabulum for the young ova. "In many cases normal nuclei of the germinal epithelium may be observed within the ovum." The ova then become surrounded by germinal epithelium, from which the follicle is formed. If in the common dab we call the epithelial cells primitive ova, the analogy is practically complete.

My study of the *egg membranes* themselves is of course confined strictly to those of intra-ovarian ova. I may preface the few statements I have to make by explaining that I accept the term "zona radiata" as used by Balfour and some others in describing the constant and most important membrane, and find it convenient to treat of other membranes as *inside* or *outside*, according to their position with regard to that membrane. What I shall call the zona radiata is, therefore, the vitelline membrane of Waldeyer, Kölliker, and others; the egg capsule of His and Müller; and the zona pellucida of Eimer.

Cunningham (**13**) describes the almost ripe ovum in the sole when the radial striæ are very distinct. The vitelline membrane (zona radiata) described by him is considered to be the only membrane present. My examination of soles' ova inclines me to the conclusion that there is a membrane inside the zona radiata, as well as the follicular layer outside. The membrane is seen to best advantage in eggs in which some slight shrinkage of the protoplasm has taken place, and fig. 10 represents the appearance as seen in an egg of this description. Scharff figures an exactly similar condition in the egg of *Trigla*, and other authors have also described it. Kupffer, when treating on the herring, compared this structure to the true vitelline membrane. Ransom calls it the inner yolk-sac—his outer yolk-sac being the zona radiata of Balfour. On the other hand, His, Waldeyer, and Brock deny its existence.

The membrane may be the product of the vitellus, or it may be derived from the zona radiata, and it is also possible that the zona

may be derived from it. The ready way in which it seems, by clinging to the yolk mass, to separate from the zona radiata, appears to favour the idea that it has no immediate relation with the latter. In this case it may be possible that, in those species in which the membrane is present, no pabulum can be supplied to the ovum from the follicular layer through the supposed radial pores. I cannot prove the origin of this structure, and therefore hesitate to give it the name of vitelline membrane. It has a very distinct double contour, and appears to be proof against stain.

What becomes of it when the ovum is shed and comes in contact with the water I am, unfortunately, unable to say. Its relation to the perivitelline space would be a point of some interest; and further, if this space contains albumen, as stated some time ago by Raffaele, and not water which has gained access through the micropyle or radial canals, a somewhat important function might be found for it.

In none of my sections do I find a membrane outside of the zona radiata. The follicular layer is often irregular in its composition, and sometimes cloudy in appearance, and a distinction between it and any outer layer of the zona radiata, therefore, would be difficult. I am inclined to think, however, that an outside membrane of this kind must occur in very few species (**14**). Brook (**15**) describes a vitelline membrane outside of the zone radiata in *Trachinus vipera*, and Balfour (**16**) notes one in the herring and describes an imperfect one in the perch, but so far as I know these are the only instances.

IV. *The Ovary.*

In treating of the whole organ I do not intend that my remarks should apply to the ovaries which, according to Jules MacLeod (**17**), constitute "la première forme"—the ovaries of Salmonidæ and Muræenidæ, where the ova are dropped into the abdominal cavity, and find their way to the exterior by abdominal pores. In the case of these fishes the arrangement of the ovary is, to a certain extent, reversed, the germinal epithelium being free, and not enclosed, so as to form a tube, by a surrounding membrane.

Although I have described the nucleoli of the conger's egg, I shall therefore not touch on its ovary, but must refer the reader to the account given by Cunningham (**18**). I shall confine my remarks to the ovaries of those fishes in which the epithelium is enclosed by a surrounding membrane, and the eggs, becoming free in the centre of the organ, are extruded through an oviduct.

The ovary is usually described as a tubular structure, and in the

unripe condition it is so; but as development of the ova proceeds, the lumen becomes more and more closed by the extension of the lamellæ towards the centre of the organ.

At the time when a section shows an appearance similar to that shown in fig. 2 the lumen disappears, and the lamellæ become indistinguishable on account of their closely packed and fused condition. Ultimately, by the thinning out and rupture of the epithelium, the almost ripe ova lie free in the organ, ready for extrusion.

The outer wall consists of fibrous tissue, which assumes different appearances according to the sexual condition of the ova. The fibres run, for the most part, in a longitudinal direction, and are therefore seen best in longitudinal sections. The outer fasciuli, however, frequently bend until they lie transversely. From the main membrane, offshoots spring towards the interior of the organ. These pass off in a curved manner, similar to the spokes of an iris diaphragm, although by no means so regularly.

The offshoots form the leading divisions of the internal arrangement, and on their branching afford support to the lamellæ in much the same way as veins do in the leaves of plants.

In what we may describe as the resting stage in the common dab—for I certainly believe that a condition of this sort obtains —when after spawning the ovary has been made up with quite unripe eggs, the outer wall has a thickness of about ·9 mm.

In following the various conditions of the ovary we find that the condition of its outer wall fluctuates in a rather singular manner, that in the cycle from one resting stage to another it thickens twice, and thins again twice. From the ·9 mm. thickness it gradually grows until, when the ova are what has been described as half ripe (fig. 2), (when the lumen of the ovary disappears) it reaches the thickness of from ·19 to ·20 mm. This is its maximum thickness in the purely laminated fibrous condition. The organ now increases rapidly in size, and as it does so the outer wall decreases in thickness, the fibrous composition being less and less evident as this goes on. When the ova are ripe the thickness is only from ·2 to ·3 mm. in the common dab.

Whenever the process of spawning releases the pressure, the wall rapidly thickens again, and when spawning is completed and the organ is in its flaccid condition, a distinct division into an outer and an inner layer is noticeable. The outer is still the normal fibrous envelope, but the inner coat becomes highly modified. Numerous nuclei make their appearance (fig. 11), and increasing by a process of division, first of all form thickened masses, and then by the bursting of the inner membrane are poured out, and form irregular masses amongst the vacuoled eggs at the periphery of the ovary.

It is to be noticed, however, that the thickened masses occur round the inner surface of the membrane only at intervals, and that the modified inner portion becomes decidedly thin at the other parts. One of the thickened masses is seen in fig. 12, the total thickness in this case being ·25 mm. Following the progress of the masses, we find that the cells thus added to the stroma continue for some time to keep together, and that those on the inner margin continue to divide rapidly, extending inwards amongst the loosely arranged ova. They often give off chains of cells which follow separate directions, twine round ova, and extend until they eventually reach the germinal epithelium. We find, in short, that the whole supporting structure of the ovary has been laid down.

These chains of cells then begin to flatten, they stain more and more deeply, the nuclei become less distinct, and the appearance becomes once more that of ordinary fibrous connective tissue.

The spaces between the fasciculi of fibrous tissue are generally considered to contain albuminous matter, and therefore with the rupture of these cells from the ovarian membrane an albuminous substance would at the same time be given to the ovary. Such a substance has been described as being present in the ovaries of Teleosts, its function being considered to be that of a lubricant, useful in allowing the eggs to be readily extruded at the spawning period. The origin of this substance may be explained in this way.

In treating on the great ova in the common dab I have stated that the quite unripe condition persists all through the autumn and winter months, that the ovary is then in a resting or inactive condition.

I am not prepared to consider this statement as applicable to all Teleosts, because in some cases, if a resting period does occur, it must be a short one. I am not even prepared to say that all Pleuronectids have a distinct resting period, because the reproductive organs of this genus, as of others, show a considerable diversity of arrangement, and the spawning periods are often widely apart. Still the condition seems also to obtain in round fishes, since I find it in the hake. A circumstance which may affect the condition very decidedly is the extent of time taken by any one species in getting rid of all its spawn. If the intervals between the expulsion of successive batches of ova are prolonged, then it follows that the anterior part of the ovary is very much later in getting into its resting condition, and that by the time it has done so a progressive change may have already set in at the periphery of the posterior or early part of the organ.

The Plaice, for instance, has a spawning period which extends over a very considerable length of time, and it also sheds a large

number of eggs in each batch—an interesting provision, by which a fish possessing somewhat bulky eggs can nevertheless extrude an unusually large number, since when all the eggs of the various batches have escaped, many more have swelled to maturity than could possibly have been contained in the ovary if all had to be shed at once, or the batches soon after one another. It seems to me, therefore, that with this condition a resting period must of necessity be at any rate much shorter than in the condition where batches of ova are rapidly extruded one after the other, until all are gone.

I should, therefore, expect that in all Salmonidæ, and fish which get rid of all their eggs at once, a long resting period was invariable. The common dab certainly does not get rid of all its eggs at once, yet has a long resting period; and if similar conditions bring about similar results in other groups, I can have no hesitation in saying that I believe a resting period is usual in Teleosts.

It may appear that I lay too much stress on this point, but with the diversity of systems of extruding the eggs, the long period during which spawning goes on, and the presence of eggs of more than one generation in the ovary, a resting period has appeared to some to be improbable.

Whenever the ova escape and the pressure on the ovary is relieved, the fibrous walls contract rapidly; and as the organ becomes empty, so it is drawn together from every point. The majority of fibres were seen to run longitudinally; the significance of this now appears, since the greatest reduction in size takes place in the long axis of the organ.

From the very greatest distension the ovary is speedily reduced to a size *almost* as small as that seen in the immature condition, the walls being then at their very thickest.

It was my original intention, in treating of the ovary, to compare the immature organ of the young fish with the resting or inactive condition in the adult; being of opinion that a decided difference could be demonstrated—a point of very decided importance. I have, however, decided against taking the matter up in this paper, since, if the subject is treated from a practical fishery point of view, the results can be more forcibly applied to that branch of work, on which it has the most important bearing.

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Fig. 6.

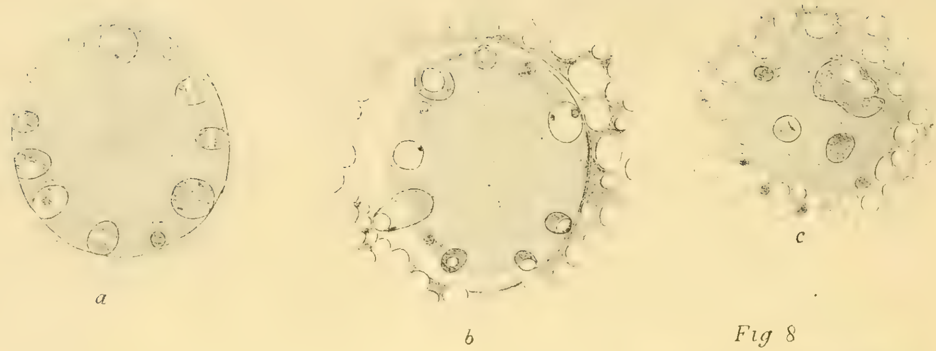
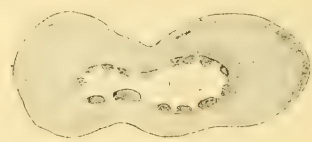


Fig 8



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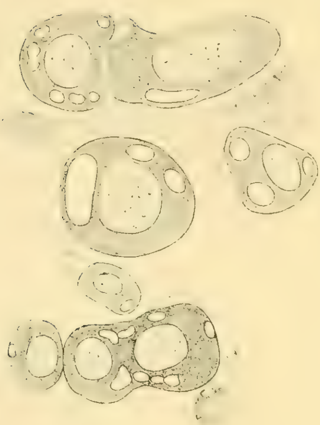


Fig 9

Fig. 10.

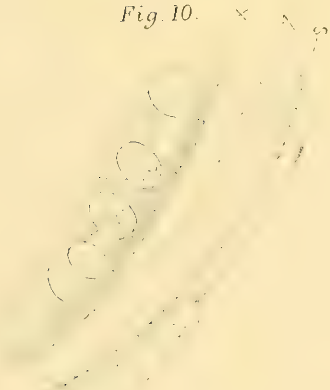
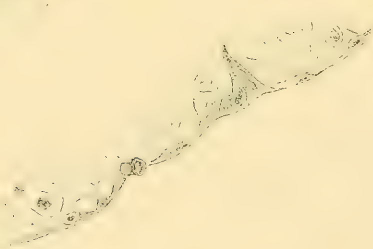


Fig. 12.

Fig 11



W. T. C. DEL. AD NAT. J. E. W.

Plate XI.

Fig 1.

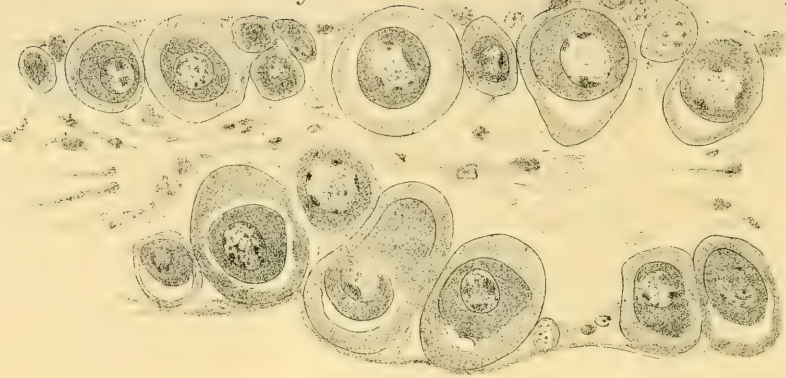


Fig 2

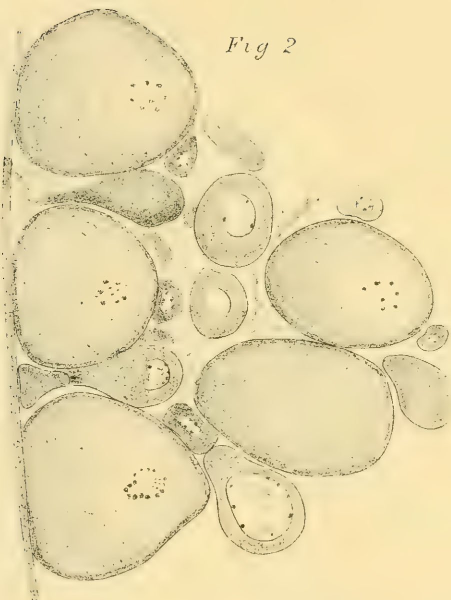


Fig. 3.

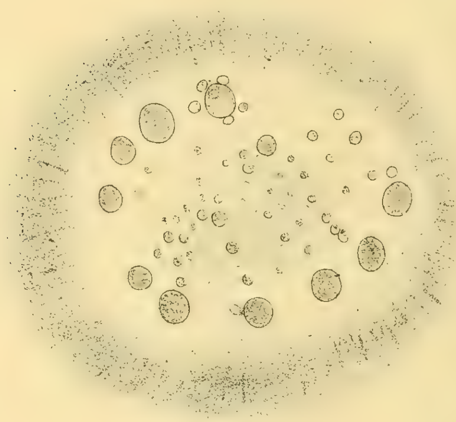


Fig. 4.

Fig 5.

W. T. C. DEL AD NAT. J.E.W.

DESCRIPTION OF PLATES XI AND XII.

Illustrating Mr. Calderwood's paper on "A Contribution to our Knowledge of the Ovary and Intra-ovarian Egg in Teleosteans."

PLATE XI.

Fig. 1.—Forming lamella of common dab, showing the ova separated into darkly stained and light zones, and the subsequent splitting of the light zone from the dark. Young ova developing from epithelial cells are seen filling up the remaining spaces of the lamella. Zeiss D, oc. 2.

Fig. 2.—Transverse section of ovary of common dab becoming ripe, showing the three sizes of ova, the great having no nuclear membrane, and the rapidly thinning ovarian wall. Zeiss CC, oc. 2.

Fig. 3.—Highly magnified nucleus of egg taken from same section as Fig. 2, showing absence of nuclear membrane and budding nucleoli. Zeiss F cor., oc. 4.

Fig. 4.—Portion of section from spent ovary of common dab, showing the three sizes of ova, large egg still with nucleoli although zona radiata disappeared; also portion of egg in advanced state of disintegration.

Fig. 5.—Transverse section of intra-ovarian ovum of conger becoming ripe. Nucleoli with circular arrangement of granules.

PLATE XII.

Fig. 6, *a*, *b*, *c*.—Three successive stages in the development of nucleus in ripening conger. *a*. Nuclear membrane distinct; nucleoli arranged regularly, numerous, showing clear bands across short axis. *b*. Showing ultimate development of clear bands into vesicles, which are expelled from the nucleoli, and merge with the yolk-spherules. *c*. Nuclear membrane gone; protoplasm encroaching on former space of nucleus; nucleoli few; vesicles still forming; nucleolar matter seen outside area. Zeiss F cor., oc. 2.

Fig. 7.—Vacuoled small ova without nucleoli dividing, taken from margin of longitudinal section of spent ovary of common dab. Zeiss F cor., oc. 2.

Fig. 8.—From same section as Fig. 7. Ovum from centre of spent ovary of common dab. Nucleoli present; ovum showing signs of division. Zeiss F cor., oc. 2.

Fig. 9.—A longitudinal section of lamella of ovary from common dab in process of being built up after spawning. It is a later condition than that seen in Fig. 4. The germinal epithelium is rapidly forming minute ova, and the follicular layer of the larger eggs is also appearing. The small masses of epithelial cells also forming minute ova are seen in various stages of development at *n*.

Fig. 10.—Section showing the egg-membranes in the almost ripe ovum of the sole. S = follicular layer. Z = zona radiata. X = the inner membrane described by Kupffer as the vitelline membrane.

Fig. 11.—Inner surface of fibrous envelope of spent ovary, showing the first appearance of the connective-tissue cells. Zeiss F cor., oc. 2.

Fig. 12.—Later stage in the development of connective-tissue cells on the inner surface of ovarian envelope, showing a collection of the cells into a mass previous to their separation from the fibrous portion of the wall. Zeiss D, oc. 2.

Note on a Large Squid (Ommastrephes pteropus, Stp.).

By

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On the 6th of January, 1892, Dr. Elliot of Kingsbridge most generously presented to the Marine Biological Association a large and interesting Cephalopod which was captured off Salcombe.

Dr. Elliot brought the squid to the Plymouth Laboratory, and it was subsequently purchased for the Oxford Museum by Prof. Ray Lankester, who requested me to identify it, giving me much kind help, for which I wish to express my sincere thanks.

The specimen in question, which I find to be a female *Ommastrephes pteropus*, Stp. (*Sthenoteuthis pteropus*, Verr.), is in very fair condition, having been preserved in chromic acid and in alcohol. The left eye is unfortunately missing, and the lateral membranes of the arms and lining of the siphon pit are somewhat torn. The principal measurements, which can only be approximate owing to the shrinking during preservation, are as follows :—Length from the extremity of the body to the edge of the mantle, dorsally, 51 cm.; length from the extremity of the body to the edge of the mantle, along the postero-ventral surface, 50 cm.; length from the extremity of the body to the level of the mouth, 66 cm. The edge of the mantle is nearly straight along its postero-ventral border, and is produced to a slight point dorsally at the end of the nuchal cartilage, as figured by Steenstrup (**3**, p. 146, fig. 3). The large "caudal fins" are transversely rhomboidal, as described and figured by Verrill (**5**, p. 229, and Pl. LIV, fig. 2 *a*). The breadth across the two is 40 cm.; they each measure 27 cm. along the posterior free edge, and 23 cm. along the dorsal line of attachment. The dorsal or first pair of sessile arms is 23 cm. long, and trapezoidal in section. The second pair is 28 cm. long, with a keel and a small lateral membrane, whose maximum width is about 1·5 cm., on the ventral border. The third or lateral pair of arms (Fig. 1) is 28·5 cm. in length; on the outer surface is a large keel, broadest

FIG. 1.

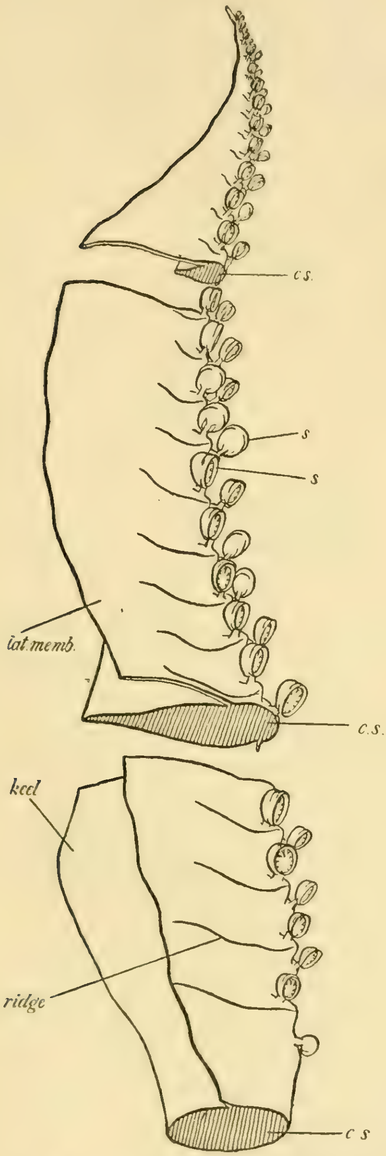

FIG. 2.

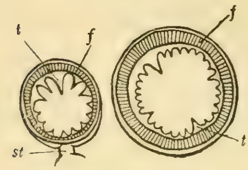

FIG. 3.

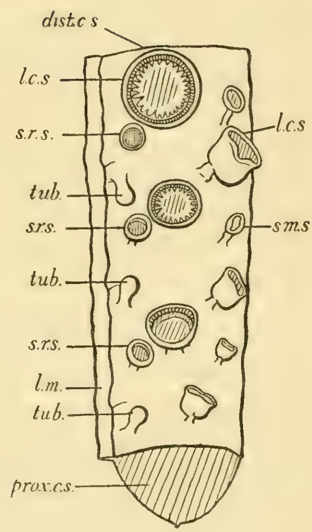

FIG. 1.—Posterior view of the third (left) arm. *Lat. memb.*, lateral membrane; *s.*, sucker; *c. s.*, cut surface. The arm is drawn diagrammatically, as if cut into three pieces.

FIG. 2.—On the left, figure of one of the suckers of the sessile arms. On the right, figure of one of the large suckers of the club of the left tentacle. *st.*, stalk or peduncle; *f.*, circular fold bearing horny plates; *t.*, teeth of horny margin.

FIG. 3.—View of the proximal part of the left tentacular club, diagrammatically drawn as if cut off. *Dist.c.s.*, distal cut surface; *prox.c.s.*, proximal cut surface; *l.c.s.*, large central sucker; *sm.s.*, small sucker; *s.r.s.*, smooth-rimmed sucker; *tub.*, tubercle; *l.m.*, lateral membrane.

below the middle of the arm. Along the postero-ventral edge of this arm extends a broad membrane (*Lat. memb.*, Fig. 1), about 5 cm. wide near the middle of the arm. This lateral membrane, which is formed by the extension of the platform on which are situated the suckers of the arm, is supported by thick ridges running out from between the suckers. The ventral or fourth pair of sessile arms is 28 cm. long, with a keel but no membrane.

All the sessile arms have along their inner surface two rows of suckers. One of these is figured (Fig. 2) to show the shape and disposition of the teeth of the horny margin (*t*, Fig. 2). A fold (*f*, Fig. 2) supporting horny plates runs round the inner edge.

The tentacular arms, 64 cm. long, are slender and clubbed. In Fig. 3 I have represented the proximal end of the club of the left tentacle as if cut off, in order to show the slight lateral membrane on the dorsal edge, and the small keel on the outer surface, which is more prominent towards the tip. There are two central rows of suckers (*l. c. s.*, Fig. 3), very large towards the middle of the club, and on each side a row of small long-stalked suckers (*s. m. s.*, Fig. 3), situated on the transverse ridges which run between the large suckers. In Fig. 2 is shown a large sucker in greater detail; round the rim internally is a circular shelf-like fold (*f.*, Fig. 2), bearing horny plates. The inner horny margin of the sucker is provided with teeth all round, four of which are large and prominent (*t.*, Fig. 2). At the proximal end of the club on the dorsal edge is the "connective apparatus," consisting of three smooth-rimmed suckers (*s. r. s.*, Fig. 3), alternating with three large tubercles (*tub.*, Fig. 3). The right tentacle bears a corresponding apparatus. The arrangement of these suckers and tubercles is similar to that described and figured by Steenstrup for *O. pteropus* (**2**, fig. 2, p. 81; and **3**, fig. 3).

From the last suckers on the club to within 15 cm. of the base of the tentacle are fourteen transverse ridges on the inner surface; they disappear gradually towards the base. Below the buccal membrane, which is provided with seven points, is a cavity communicating with the exterior by two apertures at the base of the dorsal arms, and two apertures at the base of the tentacles. Outside the base of the tentacles are two pits, or pockets.

The funnel is represented in Fig. 4 as bent back, so as to expose the pit in which it lies. It is retained by four bridles, two towards the middle line (*in. br.*, Fig. 4), and a thicker bridle on each side (*out. br.*, Fig. 4). Within the bases of attachment of the inner bridles are seen two apertures (*d. ap.*, Fig. 4), communicating with the cavity of the siphon above the valve.* Inside the external bridle is an aperture, perhaps artificial, communicating from the siphon pit

* I have observed these apertures in *Thysanoteuthis rhombus*.

to the cavity outside the bridle, which opens by the "ouverture anale" of D'Orbigny (1, p. 342). At the top of the siphon pit are seen folds which correspond pretty closely, but not exactly, to those figured for this species by Steenstrup (2, p. 79, fig. 1). There are

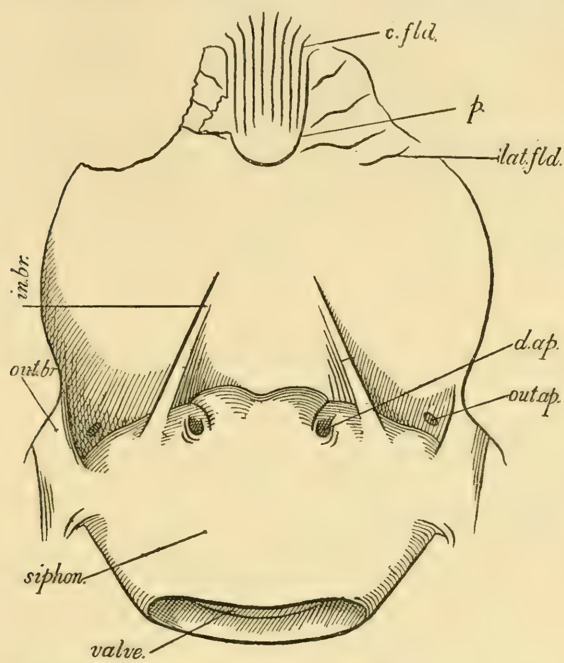

FIG. 4.—View of siphon pit, the siphon being bent down so as to expose it. *out. br.*, outer bridle; *in. br.*, inner bridle; *out. ap.*, outer aperture; *d. ap.*, aperture in dorsal or inner wall of siphon; *c. fld.*, central fold; *lat. fld.*, lateral fold; *p.*, shallow pocket or velum.

eight grooves within the central space, bounded by a U-shaped fold or velum, and four folds on either side outside it. Steenstrup figures only twelve folds in all.

The specimen before us, then, agrees with Prof. Steenstrup's species, *O. pteropus*, in size, in having very well-developed lateral membranes to the arms, a nearly straight mantle edge, numerous folds in the siphon pit, and in possessing a particular arrangement of the connective apparatus. This species, which inhabits the Atlantic, has rarely been recorded from our shores. Mr. E. A. Smith, of the British Museum, has kindly given me the following information concerning two specimens now in the Natural History Museum. One is an incomplete specimen obtained on November 19th, 1883, at Scarborough: it was 52 inches long (arms included), 25 inches in girth, and 22 inches across the fins. The second specimen is a perfect one, captured in the North Sea, February 27th,

1884. It measures from the mouth to the end of the body 39 inches; in girth 22 inches; across the fins 23 inches. The tentacles are 36 inches in length.

I have added to this note a table of the chief diagnostic characters of the well-established genera of living Oigopsid Cephalopods. It is not an attempt at a natural classification of these genera, but only a tabular statement of their characters, which may, I hope, be of some use in identifying specimens—a task by no means easy now, owing to the literature being much scattered.

For the full literature of the subject, synonyms, &c., I must refer the reader to Mr. Hoyle's excellent Catalogue of Recent Cephalopoda, published in the "Challenger" Reports, and in the Proc. Roy. Phys. Soc. Edin. vol. ix, 1886.

Table of the Chief Characters of the Genera of Recent Oigopsid Cephalopods.

A. Siphon without valve.

A. Siphon without bridles. Mantle attached to head by 3 bands. Three dorsal pairs of arms, more or less webbed.

a. Fins rounded. Eyes sessile.

a[1]. Pen simple, lanceolate.

1. Arms with 2 rows of smooth-rimmed suckers. Tentacles with smooth-rimmed suckers and slight membrane. Mantle covered with chitinous papillæ. Cranchia (Leach, 1817).

b[1]. Pen with cone.

2. Arms with 2 rows of suckers. Club of tentacles with 4 rows of blunt-toothed suckers, and group of suckers and tubercles forming connective apparatus. Prominent eyes. Seven lobes to buccal membrane. Taonius (Stp., 1861).

3. Arms short, with 2 rows of suckers. Tentacles absent in adult. Eyes prominent. Two rows of cartilaginous papillæ on mantle. Leachia (Les., 1821).

b. Pen lanceolate. Fins more or less angular. Eyes pedunculate.

4. Arms with 2 rows of stalked suckers. Tentacles with 2 rows of suckers along the stem and 4 on the club. Suckers all smooth. Eyes pedunculate (sessile in type species?). Fins terminal. Loligopsis (Lam., 1812). [Zygœnopsis, de Roche., 1884.]

5. Arms with 2 rows of sessile suckers. Tentacles long, with tubercles along stem. Fins triangular and subterminal. Pyrgopsis (de Roche., 1884).

B. Siphon with 2 bridles.

6. Arms with 2 rows of toothed suckers. Club of tentacle with 4 rows of toothed suckers. Siphon pit with velum. Pen with cone. Seven lobes to buccal membrane. Eye with sinus. Fins rounded. Steenstrupiola (Pfeffer, 1884).

B. Siphon with a valve.

A. Siphon without bridles.

7. Arms with 4 rows of smooth suckers. Club of tentacle with many rows of minute suckers. Small sinus. Pen feather-shaped. Suckers on the 7 lobes of buccal membrane. Fins subterminal, rounded. Bathyteuthis (Hoyle, 1885).

B. Siphon with 1 bridle (probably 2 fused).

8. Three dorsal pairs of arms, webbed. Socket I-shaped. Pen feather-shaped. Fins rounded. Histiopsis (Hoyle, 1885).

C. Siphon with 2 bridles.

a. Ear-shaped socket of mantle.

a^1. No sinus. Fins subterminal and rounded. Ventral arms large and with lateral membrane.

9. Arms very unequal, 2 rows of toothed suckers to first 3, and 1 row to ventral arms (?). Club of tentacle with sessile suckers and membrane, 4 rows down the stem. Spoon-shaped olfactory organ. Pen with hollow cone. Doratopsis (de Roche., 1884).

10. Arms with 2 rows of toothed suckers. Tentacles extremely long, suckers along stem, large club with long curved toothed suckers and spoon-shaped extremity. Buccal membrane with 7 lobes. Six buccal aquiferous openings. Spoon-shaped olfactory organ. Pen lanceolate. Cheiroteuthis (d'Orb., 1839).

b^1. Small sinus. Lateral membrane of arms very small.

11. Arms with 2 rows of nearly smooth suckers. Tentacles long and lash-like, numerous minute toothed suckers at end. Six lobes to buccal membrane. Pen narrow, with cone. Fins rhomboidal. Socket without pronounced tooth.
Mastigoteuthis (Verrill, 1881).

b. I-shaped socket (except Ancistrocheirus?)

a^1. Without sinus.

a^2. Fins of separate filaments.

12. First 3 pairs of arms with 4 rows of smooth suckers. Ventral arms with 2 rows, and lateral membrane. Club of tentacles with many rows of smooth suckers. Fins of muscular filaments joined only at base. (Small sinus?).
Chtenopteryx (Appelöf, 1888).

b^2. Fins rhomboidal. Pen lanceolate.

13. Arms with 2 rows of toothed suckers. Tentacles long and slender, with suckers along whole length; club with lateral membrane and numerous small suckers. Lobes of buccal membrane indistinct.
Brachioteuthis (Verrill, 1881).

c^2. Fins rounded.

a^3. Pen with cone.

14. Arms with 2 rows of suckers, smooth proximally and toothed distally. Club of tentacle with 4 rows of smooth suckers and group with tubercles (conn. app.). Buccal membrane with 7 lobes. Pen broad, hollow, bent at tip, and with small cone. Calliteuthis (Verrill, 1880).

b^3. Pen lanceolate.

15. Arms with 2 rows of suckers, the 3 dorsal pairs of arms joined by a web, and the ventral joined by a web. Tentacle with 6 rows of toothed suckers on club, and conn. app. extending down the stem, cluster of smooth suckers at tip. Four buccal and 2 brachial aquiferous openings. Buccal membrane with 6 lobes.
Histioteuthis (d'Orb., 1839).

b^1. With sinus.

a^2. Without hooks.

a^3. Pen with cone. Nuchal crests small or absent.

16. Arms with 2 rows of toothed suckers and slight web. Club of tentacle with 4 rows of toothed suckers distally and 10 rows of smooth suckers proximally. Buccal membrane with 7 lobes. Fins rounded.
Tracheloteuthis (Stp., 1881).

17. Arms with 2 rows of toothed suckers. Club of tentacles with 4 rows of toothed suckers and lateral membrane. Conn. app. extending along the stem, cluster of smooth suckers at tip. Fins forming an arrow-head.
Architeuthis (Stp., 1856).

b^3. Pen lanceolate. Nuchal crests.

18. Arms with 2 rows of smooth suckers. Tentacles mere stumps. Chaunoteuthis (Appelöf, 1890).

b^2. With hooks. Fins rhomboidal. Conn. app. at base of club, and generally group of suckers at tip.

a^3. Pen lanceolate.

a^4. Fins terminal. Suckers to tentacles.

19. Arms with 2 rows of hooks. Tentacles short, suckers few. Pen slender, cartilaginous. Fins somewhat rounded, terminal. Verania (Krohn, 1847).

b^4. Fins subterminal generally. Hooks to tentacles.

a^5. Hooks to arms and tentacles. Very large fins.

20. Arms with 2 rows of hooks. Tentacles with hooks on club. Fins large, along nearly whole length of mantle, subterminal. Socket ear-shaped (?). Ancistrocheirus (Gray, 1849).

b^5. Hooks and suckers to arms and tentacles.

21. Arms with 2 rows of hooks and a few suckers. Club of tentacles with hooks. Buccal membrane with 8 lobes. Fins slightly rounded. Enoploteuthis (d'Orb., 1839).

22. Arms with 1 row of hooks near base and 2 rows of suckers near tip. Club of tentacles with alternate hooks and suckers. Abralia (Gray, 1849).

b^3. Pen with cone.

a^4. Only suckers on arms in 2 rows. Hooks and suckers on tentacles. Buccal membrane with 7 lobes.

23. Arms with two rows of smooth suckers, and lateral membrane. Club of tentacle with 2 rows of hooks. Two brachial and 6 buccal aquiferous sacs. Solid cone to pen. Onychoteuthis (Licht., 1818).

24. Arms with two rows of suckers. Club of tentacles with 2 inner rows of hooks, and 2 outer of toothed suckers. Cone of pen solid at apex. Teleoteuthis (Verrill, 1882).

25. Arms with 2 rows of smooth suckers. Club of tentacles with 2 rows of hooks. Cone of pen hollow. Ancistroteuthis (Gray, 1849).

b^4. Hooks and suckers on arms in 4 rows.

26. Ventral arms with 4 rows of suckers, the other arms with 2 rows of hooks within and 2 rows of suckers without. Hooks on tentacles. Buccal membrane rounded. Pen with hollow cone. Fins reach beyond tip of body. Gonatus (Gray, 1849).

c. Socket with large tooth or process.

27. Arms with 2 rows of toothed suckers and lateral membrane. Club with 4 rows of toothed suckers and conn. app. extending along the stem. Sinus. Two apertures at back of siphon. Pen lanceolate. Long fins along whole length of the mantle. Thysanoteuthis* (Troschel, 1857).

D. Siphon with 4 bridles, and 2 apertures at back. $\perp$-shaped socket. 2 brachial, 2 anal, and 4 buccal aquiferous openings. Buccal membrane with 7 lobes. Three longitudinal nuchal crests. Eye with sinus. Pen with hollow cone. Arms with 2 rows of toothed suckers.

a. Folds in siphon pit absent, or only within the velum.

28. Smooth siphon pit. Little or no lateral membrane to arms. Teeth absent or blunt on large suckers of club. Illex (Stp., 1880).

29. Folds in siphon pit within the velum. Lateral membrane of arms small. Alternate sharp and blunt teeth on one half the circumference of large suckers of club. Todarodes (Stp., 1880).

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* A small specimen of Thysanoteuthis rhombus, Trosch., presented to the Oxford Museum by Prof. Ray Lankester, appears to possess 4 bridles; this may perhaps be due to the artificial splitting of a single pair.

b. Folds in siphon pit within and without the velum. Lateral membrane of arms large. Large suckers of club with 4 large teeth, and small teeth all round.

30. Suckers of arms moderate in size and number.
Ommastrephes (d'Orb., 1835).

31. Suckers of arms long-stalked and crowded.
Dosidicus (Stp., 1857).

List of Works referred to.

1. D'Orbigny et Férussac, Hist. nat. des Céphalopodes acétabulifères, Paris, 1835—1848.

2. Steenstrup, *Orientering i de Ommatostreph. Blæksprutters,* Oversigt Kong. Danske Vid. Sels., 1880.

3. Steenstrup, *Notæ Teuthologicæ,* Oversigt Kong. Danske Vid. Sels., 1887.

4. Verrill, *Ceph. N. E. America,* Trans. Connect. Acad., vol. i, part 1, 1880.

Notes on Centrina Salviani.

By

W. L. Calderwood,
Director of the Laboratory.

With Plate XIII.

Two specimens of this Elasmobranch have recently been landed at Plymouth, the one on the 21st of June, and the other on the 8th of July. They were both captured by steam trawlers working off Vigo Bay on the north-west coast of Spain. The specimens cannot, therefore, be claimed as English; but since only one example appears to have been previously landed in this country, having been taken off the coast of Cornwall in 1877; and since the fish is, therefore, not at all well known, a few notes on the two specimens brought to the Laboratory may be of interest.

In looking up the literature on this fish I do not find a drawing which gives a satisfactory idea of its appearance. I have, therefore, attempted to represent one of the specimens in question by an accompanying figure.

The following measurements will also help to give a comprehensive idea of the proportions :

Extreme length	31	inches.
Extreme breadth of flat ventral surface . .	$5\frac{1}{2}$	,,
Breadth of mouth	$1\frac{1}{8}$	,,
Breadth between grooves on each side of mouth	2	,,
Length from centre of spiracle to end of snout .	3	,,
Longitudinal measurement of eye . . .	$1\frac{1}{8}$	,,
,, ,, spiracle . .	$\frac{3}{4}$	inch.
,, ,, gill-slits . .	$\frac{3}{8}$	,,
Length of abdominal cavity	17	inches.
Breadth ,, ...	$4\frac{1}{2}$	,,

The other specimen measured 35 inches in length.

Günther's description of the genus, of which *Salviani* forms the only species, is as follows :

"Two dorsal fins, each with a strong spine ; no anal fin. Trunk rather elevated, trihedral, with a fold of the skin running along each side of the belly. Mouth narrow, with a deep groove on each side. Teeth of the lower jaw erect, triangular, firmly serrated ; those of the upper slender, conical, forming a group in front of the jaw. No membrana nictitans. Spiracles wide, behind the eye. Gill-openings narrow.

"Mediterranean and neighbouring parts of the Atlantic."

The ventral aspect is perfectly flat, suggesting the idea that the habit of the fish is to frequent the bottom, and to lie in one position for long periods. The mouth also is extremely oblique in its opening, and provided with deep grooves resembling the appearance found in the skate. The eye, in proportion to the size of the head, is large, and the heavy lids can easily be drawn so as to cover the eyeball completely. The pupil has a somewhat singular appearance. It is elliptical in outline, the long axis being vertical.

The skin is a remarkable feature, its extreme roughness being at once apparent to the eye and rasping to the touch.

Each scale or dermoid denticle is irregularly pyramidal, presenting, a sharp apex. The scales are so arranged as to form a close covering of a diamond pattern, so hard as to be almost impenetrable to steel. I have not seen any Elasmobranch which, in proportion to its size, is so completely enveloped in "kosmin." A large *Læmargus* will show the placoid scales of equal height, but not with the same sharpness of point or closeness of base.

One specimen when received had already had the abdominal viscera removed. The other was a female. The ovaries were filled with eggs, and extended the entire length of the abdominal cavity. The eggs were in some cases of great size, the largest being two inches in diameter. The oviducts had enlarged uterine dilatations, the inner surfaces of which were covered with a dense mass of vascular villi, the muscular layer being thrown into longitudinal folds. A shell gland of a somewhat rudimentary character was present on the anterior portion of each oviduct. Two large abdominal pores were present in the posterior part of the cloaca. Both oviducts opened internally by a single wide aperture situated at the anterior end of the abdominal cavity.

The intestine had no convolution, but was divisible into an extremely short small intestine and the usual spiral colon.

The liver was composed of two large lateral lobes, reaching to the posterior end of the abdominal cavity, and a small middle lobe.

Stomach empty. Spleen in two portions, one in front of the stomach and one in the mesentery of the large intestine. Pancreas and rectal gland present.

As in other Elasmobranchs destitute of a nictitating membrane, the cartilaginous skeleton shows a more or less primitive arrangement. The notochord is not continuous through the centra of the vertebral column, but the column itself is entirely cartilaginous, the centra corresponding with the neural arches. The interneural pieces exactly resemble the neurapophyses inverted, and are interposed between them like wedges, the apices reaching the centre as in *Acanthias*. No pleurapophyses are present.

The conspicuous spines which support each dorsal fin also mark a certain resemblance to *Acanthias*. There is, however, a distinct difference in that the spines of the spur-dog pass off from the neural arch of the vertebral column in exactly the same direction as, and are parallel to, the anterior margins of their dorsal fins ; whereas in *Centrina* the spines run in opposite directions, the anterior one pointing forwards, the posterior one backwards.

In both cases they correspond, in position and arrangement, to modified neural spines, but in the fleshy fin of *Centrina* there is no arrangement of supporting cartilaginous plates as seen in the fin of *Acanthias*.

The position of each spine is suggested in the figure.

Plate XIII.

W. . . DEL AD NAT

CENTRINA SALVIANI

Ichthyological Contributions.

By

J. T. Cunningham, M.A.

With Plate XIV.

1. Zeugopterus norvegicus (Günther).

In my paper in the preceding number of this Journal I erroneously described several specimens of this species as *Zeugopterus punctatus*, not having carefully examined or compared them. Since then, having seen specimens of *Zeugopterus norvegicus*, and re-examined my own, I find that my specimens belong to this species. The record of their capture in the neighbourhood of Plymouth is—

July 9th, 1891, between Eddystone and Rame Head, 25 fms., four specimens, 3 ♀, 6·2, 6·5, 9·5 cm.; 1 ♂ 8·2 cm. in length.

March 21st, 1892, six miles from Plymouth Breakwater, about 27 fathoms, one specimen ♀, 8·4 cm. long. The last specimen was a ripe female, yielding ripe ova ·9 mm. in diameter, with a single oil-globule ·15 mm. in diameter.

In Günther's British Museum Catalogue, 1862, this species was only stated to occur on the west coast of Norway. In 1864 Couch recorded the capture of a specimen in the Bristol Channel in 1863. In a paper published in 1888 Günther recorded that he had obtained a specimen 2 inches long in 1868 from a depth of 90 fathoms off Shetland, and that three specimens taken in the Firth of Clyde, at depths of 6 to 45 fathoms, occurred among fishes captured by Mr. John Murray on the west coast of Scotland in 1887 and 1888. Two of the Clyde specimens were 3½ inches (8·9 cm.) long, the third somewhat smaller. Lastly, Mr. Holt obtained a specimen during the survey of the fishing-grounds on the west coast of Ireland in the s.s. Harlequin in 1891. This specimen was obtained at 30 fathoms in Donegal Bay in May, 1891, and is recorded in Mr. Holt's report on the survey, published in the Report of the

Council of the Royal Dublin Society for 1891, and also in the Proceedings of that Society, vol. vii, pt. 4.

It was the inspection of this Irish specimen which led me to identify my own, and I have to thank Mr. Holt for kindly supplying me with references to the literature of the subject. I have now given all the recorded occurrences of this species on British coasts, and it will be seen that it appears to be occasionally fairly common in the Firth of Clyde and off Plymouth Sound, while only single specimens have been taken in the Bristol Channel, Donegal Bay, and off the Shetland Isles.

The species was originally described by Scandinavian zoologists, but first correctly distinguished by Günther. Couch's description and figure are fairly good, but not so satisfactory as those given by Günther in his report on Mr. Murray's collection from the west of Scotland. Day unfortunately failed to recognise the validity of Couch's description of this species, and placed the name used by that author as a synonym of *Zeugopterus unimaculatus;* and as I generally use Day's work, this was the reason that I at first confused the species with *Z. punctatus.* I prefer to use the generic name *Zeugopterus* for this form, rather than *Rhombus,* with which Günther unites it, on account of its evident affinities with *Z. punctatus,* and the difference between these forms and the turbot or brill. One important character, which unites the so-called topknots, namely, *unimaculatus, punctatus,* and the present species, is that the dorsal and post-anal fins are prolonged posteriorly on to the lower side at the base of the tail, towards the middle line of that side. The following is a list of the passages relating to *Zeugopterus norvegicus* cited in the preceding remarks:

J. Couch, Fishes of British Islands, 1864, vol. iii, p. 175, pl. clxvii.

Albert Günther, Brit. Mus. Catalogue, vol. iv, p. 412.

Idem, *Report on Fishes obtained by Mr. J. Murray, &c.,* Proc. Roy. Soc. Edinburgh, No. 127, Session 1887–8, p. 217, pl. iv.

E. W. L. Holt, *Report on the Results of Fishing Operations, Survey of Fishing-grounds of West Coast of Ireland,* Proc. Roy. Dubl. Soc., vol. vii, pt. 4.

Idem, *Preliminary Note on the Fish obtained during the Cruise of the s.s. "Harlequin,"* 1891, Proc. Roy. Dubl. Soc., vol. vii, pt. 3, p. 218.

Zeugopterus punctatus is by no means uncommon in the neighbourhood of Plymouth. It is frequently taken by shrimp trawlers in the Sound, and brought in alive to our aquarium. I have four specimens, 11·4 to 15 cm. ($4\frac{1}{2}$ to $5\frac{7}{8}$ inches) in length; and also a young specimen 5 cm. long, taken in the Sound on October 21st, 1889.

This specimen was probably only six or seven months old, having been hatched in the preceding spring.

Zeugopterus unimaculatus, Risso, must be extremely rare on this coast. I have never yet met with a specimen. The collection made by Mr. Murray in 1887 and 1889 included only one specimen, taken in the Firth of Clyde off Ardrossan.

2. On a Stage in the Metamorphosis of Solea.*

Plate XIV, fig. 2.

The larva represented in fig. 2 was obtained by Mr. F. W. Gamble on August 9th, when working with a hand-net among the fronds of Laminaria on the inner side of Plymouth Breakwater. It evidently belongs to the genus *Solea* from the shape of the snout, mouth, and head generally. The larva was 11 mm. long. The dorsal fin-rays are eighty-six in number, the post-anal sixty-eight, so that it is certainly either *Solea vulgaris* or *lascaris*. I have not been able to discover any indication of the enlarged nostril on the lower side which distinguishes *lascaris*, and am therefore inclined to believe that the specimen belongs to the common sole. The chief difficulty in thus regarding it is the date of its occurrence. I have taken completely metamorphosed young soles in Mevagissey Harbour on May 15th, but they have not been seen there later. However, I know that a few soles are spawning in May, although a great many are then spent. But the larva here in question could not be much more than a month or five weeks old, and must, therefore, have been spawned late in June or early in July. It is possible that some soles spawn as late as this, although I have not observed any ripe specimens in these months. The specimen when alive was very transparent, as shown in the figure. The drawing was made with the camera lucida, so that its proportions are accurately correct to scale; but the exact number of the fin-rays has not been reproduced in the figure.

There are several points of interest and importance in this larva. It shows in the first place that in *Solea*, as in the genus *Pleuronectes* —the plaice and flounder, for example—the eye of the lower side passes round the edge of the head to reach the upper side, and not

* While these pages were in the press I noticed, on referring to Raffaele's paper (*Mitt. Zool. Stat. Neapel*, Bd. viii, tav. iii, figs. 8, 9), that a similar stage of Solea is there described and figured. Thus the fact that the left eye reaches the right side in Solea by passing in front of the dorsal fin was already known, but as Raffaele's description and figures scarcely do full justice to this intermediate stage, the description and figure I have given are by no means superfluous.

through the tissues of the base of the anterior part of the dorsal fin. It is well known that Steenstrup in 1863 described transition stages of Pleuronectids, obtained from the North Atlantic, in which the eyes, after metamorphosis, were on the left side, and the right eye passed through the head to reach that side. He considered these stages to belong to the genus *Plagusia*. Agassiz in 1878 (Proc. Amer. Acad. Arts and Sci., vol. xiv) described transition stages, quite similar to those of Steenstrup, captured at the mouth of Newport Harbour, and ascribed them likewise to the genus *Plagusia*. Emery, the Italian ichthyologist, has pointed out that these specimens of Steenstrup and Agassiz certainly do not belong to the genus *Plagusia*, because in the latter the dorsal and post-anal fins are continuous with the caudal, and in these specimens they are quite distinct and separate. Without discussing the question at length, or carefully examining the evidence, Emery suggests that the North Atlantic specimens belong to the genus *Rhomboidichthys*. Emery, in the same paper, describes another larval form in which the longitudinal fins are continuous with the caudal, and the right eye passes through the base of the dorsal fin to the left side of the head. He did not succeed in identifying this larva with any known adult species. The larvæ in which this process of perforation has been hitherto described are sinistral, the eyes are on the left side; but nevertheless, considering the great anterior prolongation of the dorsal fin in the adult sole, it seemed not impossible that the migration of the lower eye should take place in that species also by perforation. The larva now described proves that this is not the case, its dorsal fin being still behind the left eye. The left eye has not quite reached the edge of the head; it is still on the left side, but it is very near the edge; and when the larva is examined on a slide, lying flat on its left side, the cornea of the left eye is seen to project slightly beyond the edge of the head, as seen in the figure.

The next important feature in this larva is the presence of an air-bladder of considerable size. Hitherto, so far as I am aware, an air-bladder in larval Pleuronectidæ has only been observed in the turbot and brill. I have never seen a trace of it in species of *Pleuronectes*. In that stage of the flounder which corresponds to the stage of *Solea* here described, and which I have frequently examined, no trace of an air-bladder is visible (compare the pl. xvii, fig. 5, of my *Treatise on the Sole*). No air-bladder is present in the adult sole; and in the stage just after the completion of the metamorphosis, when the little sole is 12 to 15 mm. long, the organ has already disappeared (see pl. xvi, fig. 5, op. cit.).

It is interesting to notice that in this larval stage some of the specific characters are already developed. I refer especially to the

shape of the snout and the position and structure of the mouth. The edge of the upper lip on the right side is curved, as in the adult sole; teeth are absent from the jaws on the right side, present in the lower jaw on the left. The intestine, however, does not reach its adult condition till a much later period. In this stage it has only one coil, and the posterior part does not extend backwards behind the median body-cavity. The coloration is not reproduced in the figure: it consisted of black and orange specks (chromatophores) and more diffuse patches of lemon-yellow. The pigment was not arranged in the markings which characterise the adult, and which are already visible in the early post-larval stage figured in my treatise. On the body and head the specks were pretty uniformly distributed, but on the dorsal fin there were three pigmented regions, one at the anterior end, one in the middle, and one near the posterior end. On the post-anal fin there was only one pigmented area of considerable extent, opposite the posterior area of the dorsal fin.

In my *Treatise on the Sole* I was only able to figure the newly hatched larvæ and the earliest post-larval stage. Three other larval stages were figured and described in vol. ii, No. 1 of this Journal (pl. iii). The stage here described is intermediate between the latter and the first post-larval stage, and fills up an important gap in the series, although additional intermediate stages are still required. My use of the terms larval and post-larval differs from that adopted by Professor McIntosh and some of his pupils, who restrict the former term to the stages prior to the absorption of the yolk, and call subsequent stages post-larval. I cannot see any justification for this application of the terms. A fish is a larva until the most important organ-systems of the adult, such as the permanent skeleton and fins, are developed.

3. A Larval Stage of the Mackerel.

Plate XIV, fig. 1.

In the first number of the current volume of this Journal (vol. ii, No. 1, p. 71, pl. iv, fig. 7) I described and figured the newly hatched mackerel larva. Last year I made further experiments in hatching and rearing the larvæ of this species from artificially fertilized eggs, using a hatching box of Captain Dannevig's pattern. I succeeded in keeping some of the larvæ alive four days after hatching, and the condition then reached is shown in fig. 1.

In this stage the yolk is almost entirely absorbed, but a remnant

remains containing the oil-globule, which is still conspicuous. The mouth is developed and open, and indications of the gill arches are seen behind the head. The intestine has increased so much in length that it makes a single coil in the neighbourhood of the stomach. The pectoral fin is rather large. The choroid of the eye is deeply pigmented. With regard to the pigmentation of the skin, only the position of the chromatophores is represented in the figure. The black were arranged in a series along the dorsal and ventral edges of the body, and in a group about the oil-globule. There was no pigment at all in the larval median fin-fold. The iris of the eye appeared bright blue, and there was a large irregular patch of light yellow close behind the eye on the side of the head. In my figure of the newly hatched larva I represented the pigment as black and green, the green colour being present not only behind the eye, but round the oil-globule and at three other points. The explanation of the difference is that the green colour is due to the mixture of black and yellow pigments, as in the adult mackerel. In the larva at present described the yellow pigment is not mixed with the black, and its appearance is therefore not altered. I do not suppose that the distribution of pigment in the larva now described is absolutely constant in all larvæ at this stage—on the contrary, I believe it is subject to considerable individual variation; but the absence of chromatophores from the median fin-fold appears to be constant and characteristic of the mackerel.

DESCRIPTION OF PLATE XIV.

Fig. 1.—Larva of *Scomber scomber*, the mackerel, drawn June 15th, 1891, hatched June 11th. Zeiss A_3, oc. 3, camera. Actual length 4·3 mm.

Fig. 2.—Larva of *Solea vulgaris* (or *S. lascaris*), caught August 9th, 1892. Drawn from life with camera lucida. Actual length 11 mm. *a, b.* Air-bladder.

4. Growth of Young Herring in the Thames Estuary.

I am indebted to Mr. E. W. H. Holdsworth, author of the well-known work on *Deep Sea Fishing and Fishing Boats,* for some references to passages bearing on this subject which had not come under my notice when I wrote my paper on the *Rate of Growth of Sea Fishes* for the previous number of this Journal. In that paper (see last number, pp. 240, 241) I stated that I had been unable to find any record of observations on the spawning of herring at the mouth of the Thames in spring. Mr. Holdsworth has directed my

Fig. 1.

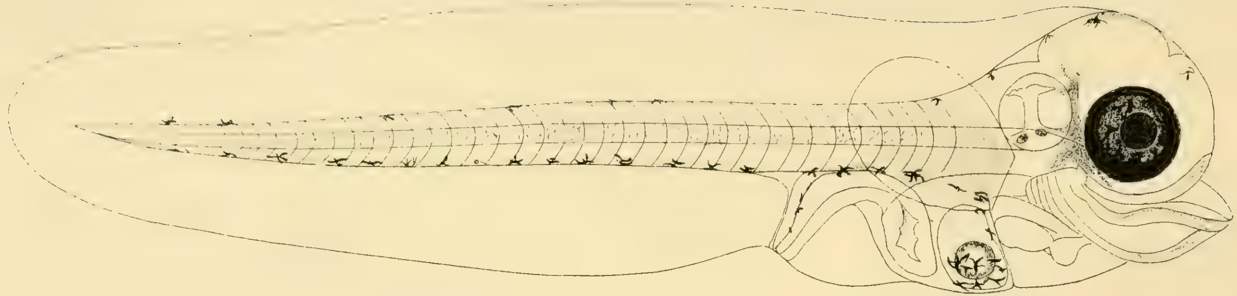
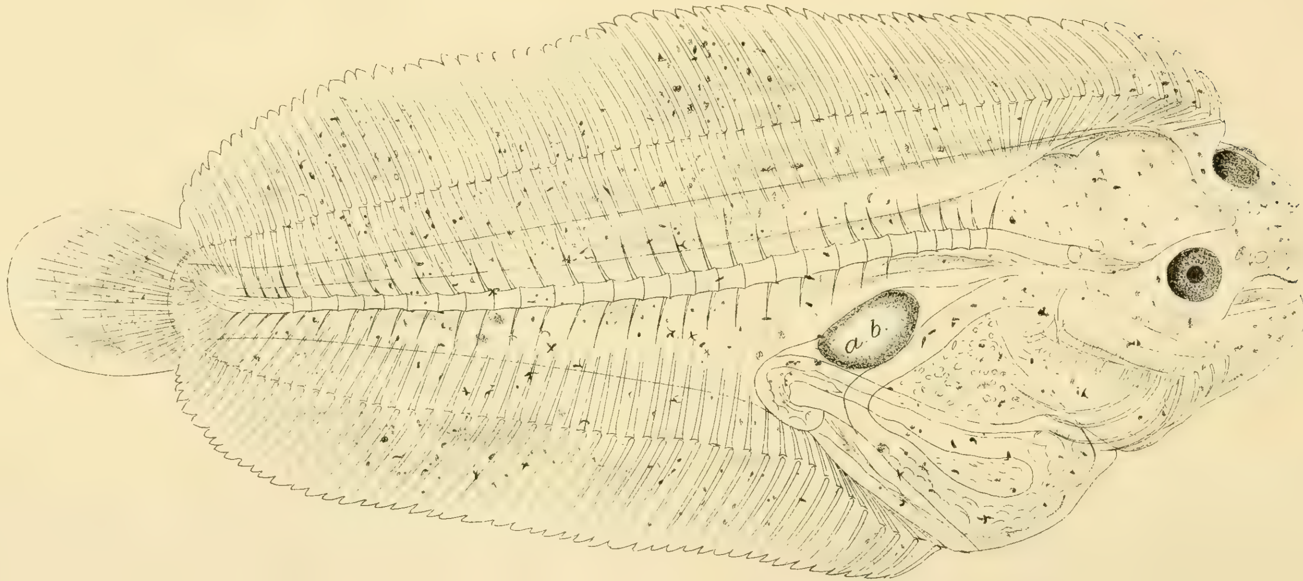


Fig. 2.



attention to such a record in Yarrell's *British Fishes*. In that work, first edition, 1836, vol. ii, p. 117, is an account of what the author believes to be a distinct species of herring, which he calls Leach's herring, *Clupea Leachii*. Yarrell says that he found herring of this sort among the fish taken at the mouth of the Thames during winter by the sprat fishermen. He points out that the common herring deposits its spawn towards the end of October, and says that numbers of the young of these herring are taken with the sprats. These are yearling herring, have the elongated form of the common herring, and although reaching 7 inches in length are without roe. The herring of the new species is found heavy with roe at the end of January, and does not deposit its spawn till the middle of February. Its length is not more than 7½ inches, and its depth near 2 inches. The characters by which Yarrell distinguishes this species from the common or autumn herring are not very salient, but it is quite possible that they correspond to those in which, according to Heincke, the spring race of herrings differs from the autumn race. The principal are the greater depth of the body and the more anterior position of the dorsal fin. However, whether these herrings are structurally distinct or not, the important fact is that Yarrell found them spawning in the middle of February. I inferred in my previous paper, from the occurrence of the larval herrings in Thames whitebait, that the parents of the latter spawned in March, April, and May; and it is not improbable, considering that Yarrell did not fully determine the limits of their spawning period, but only states that they did not spawn until the middle of February, that he only noticed the commencement of the spawning, which may have continued till the middle of May. Mr. Holdsworth, in his book on Deep Sea Fishing, p. 249, refers to Yarrell's account of Leach's herring in the Thames, stating that a more extensive examination has resulted in ranking it only as one of the numerous races of the common herring. He states also that this "small variety" of herring appears in the Wash in December, and spawns in February and March, and that it is there the object of a regular but not very extensive fishery.

Mr. Holdsworth further points out in his letter to me that he states in his book that the herring fishery takes place at Ramsgate in October and November, not the spawning, as in the citation given in my paper. With regard to the spawning, the statement in his book is that the herring are full at the eastern end of the Channel in November, and his impression is that the end of that month would be the general spawning-time in that locality. I am glad to correct this slight inaccuracy in my quotation of Mr. Holdsworth's observations. I assumed that some ripe, spawning herring were

taken at Ramsgate in the first part of the fishing season, in October; and although Mr. Holdsworth doubts the validity of this assumption, it agrees with Yarrell's statement, already quoted, that the common or autumn herring deposits its spawn towards the end of October, supposing that this statement is intended to refer to the mouth of the Thames, which is probable, but not quite certain from the context.

Notes on the Marine Invertebrate Fauna of Plymouth for 1892.

By

Walter Garstang, M.A.,
Naturalist in Charge of the Dredging Operations, M.B.A.

The following faunistic notes are offered as an indication of the chief results which have characterised our collecting operations during the present year. It is hoped that, short as they are, they may prove serviceable to British naturalists desiring to pursue special researches in marine zoology, but undecided as to the locality most likely to meet their needs. The notes are incomplete, owing to my absence from Plymouth during the earlier part of the year; but they are sufficient for the formation of an inference, since the results here described were obtained for the most part during only a fragment of the year—from June to September.

I have not discussed the peculiarities which have characterised the floating fauna, since Mr. Bles, who has been specially pursuing planktological researches, is publishing a note upon his observations in the same number of this Journal.

In future numbers I hope to give a systematic account of the fauna characterising the different bays and natural areas which are within the reach of the routine dredging and collecting operations of the Laboratory. Such an account will, I trust, be useful to naturalists visiting the Laboratory, and will also be so arranged as to form a contribution towards the general subject of marine bionomics.

The dredging, tow-netting, and trawling work of the Laboratory is, however, carried on at present under difficulties* which can hardly be adequately realised. The frequent breakdowns of the small and antiquated launch belonging to the Association seriously interfere with the continuity of our work, and needlessly limit the scope of our operations. A new and seaworthy steamboat has become an absolute necessity.

Porifera.—A specimen of *Leucosolenia lacunosa* (Bwk.), a rare and

* These difficulties, I learn, are, happily, nearly at an end (October 17th).

beautiful calcareous sponge, was dredged* in 25 fms. on September 14th, attached by its slender stalk to an old egg-case of *Scyllium canicula,* which was itself adhering to the stem of a *Gorgonia.*

HYDROZOA.—A colony of Norman's *Tubiclava* (*Merona*) *cornucopiæ,* consisting of from 90 to 100 polyps, was dredged in 15 fms. water on June 10th. The colony covers almost the whole of the upper side of the shell of an *Aporrhaïs,* tenanted by a *Phascolion strombi.* Several interesting points, in which I have been able to supplement Dr. Norman's original description, will be found described in a paper contributed by me to the Transactions of the Devonshire Association for the present year. The original specimens of *T. cornucopiæ* were dredged thirty years ago among the Shetlands, in from 80 to 100 fathoms of water.

Several additional colonies of *Haloikema Lankesterii* (G. C. Bourne) have been dredged, but the description of these is for the present deferred.

SCYPHOZOA.—In a little creek beyond the breakwater *Haliclystus octoradiatus* (= *Lucernaria auricula*) has been discovered in hundreds, attached to *Ceramium* and *Enteromorpha,* between tide-marks. The early part of the spring would be the time at which the development of this form could be followed out.

ANTHOZOA.—The Actinians of Plymouth present a valuable field for special investigation. On June 28th a specimen of one of the varieties of *Eloactis Mazeli* (Jourd.) was trawled by us a few miles off the Mewstone, and furnishes an interesting addition to the British fauna. It has been fully described in my paper read to the Devonshire Association last July.

Actinia equina, Anemonia sulcata, Cereus pedunculatus (*S. bellis*), *Thoë sphyrodeta, Cylista undata* (*S. troglodytes*), *Urticina felina* (*T. crassicornis*), and *Corynactis viridis* are all common at Plymouth. *Cylista viduata* is rare within the Sound, although common enough in the neighbourhood. *Bunodes coronata* and *Ballii* both occur, the former in Whitsand Bay, the latter on the breakwater. Of *Bunodes Ballii,* the typical pink-spotted variety, which is very common on the shores of the Isle of Wight, is rare here, and is replaced by the varieties *dealbata* and *livida* of Gosse. In addition to the above, several interesting forms that appear to be undescribed are quite common in certain localities.

TURBELLARIA.—Mr. Gamble's researches during the present summer have revealed the existence of a Rhabdocœle fauna unparalleled in the number of its species, and upon which we may expect a special report in an early number of the Journal.

NEMERTEA.—For a similar reason there is no need that anything

* Two additional specimens have since been taken.

should here be stated concerning the Nemertines of Plymouth, since they are being specially investigated by Mr. Riches.

ANNELIDA.—This large group will require considerable time before it can be adequately treated from a faunistic point of view. The dredge is constantly bringing to light the existence of species whose presence has been hitherto unsuspected. The permanent haunts of *Gattiola spectabilis* have been discovered. *Myxicola* has been added to our lists. *Staurocephalus rubrovittatus* (Grube), a remarkable little Eunicid which has hitherto been found* exclusively, I believe, in the Mediterranean, has been taken on several occasions. Where the bottom is muddy, a species of *Chætozone* has been taken in quantity, and *Polydora ciliata* builds its mud tubes in thousands upon the stones and shells brought up in the dredge.

The Gephyrea are represented by a small species of *Phascolosoma*, which is abundant in the crevices of shaly rocks between tide-marks, *Phascolion strombi*, and *Thalassema Neptuni*.

Phoronis, whose occurrence at Plymouth I recorded some time since, proves to be quite plentiful in certain parts of the Sound, and its beautiful larva has been a feature of the autumn tow-nettings.

POLYZOA.—The localities for the different members of this large group are being gradually established. Beyond the fact of the common occurrence of *Pedicellina*, however, there is nothing that calls for special notice, unless it is that *Crisia denticulata*, which Mr. Harmer, in his paper on the British species of *Crisia*, mentions as having been seldom found at Plymouth, proves to be abundant in the deeper waters a few miles outside the breakwater.

ECHINODERMATA.—*Antedon rosacea* remains a constant element in the fauna, and its Pentacrinoid larva has been taken in some numbers during the autumn.

Solaster papposus has been the most plentiful starfish this year; and, among Ophiuroids, *Amphiura elegans*, *Ophiothrix pentaphyllum*, and *Ophiocoma nigra*.

Holothuria nigra and *Ocnus brunneus* have been taken in quantity.

MOLLUSCA.—Numbers of minute specimens of *Solen* were fished during June, and showed the early development of the gill-plates in a beautiful manner through their perfectly transparent shells.

The principal additions to the Gastropod fauna have been in the Opisthobranchiate section, but it may be mentioned that two favourite Prosobranchs, *Emarginula reticulata* and *Phasianella pullus*, have been found in quantity, the former inhabiting shell-banks in about seven fathoms of water, the latter feeding upon filamentous red-brown algæ in various parts of the Sound.

* Grube, I find, records a specimen in his St. Mâlo list, so that the species is probably not uncommon in the Channel waters.

Philine punctata, of which only a single specimen was recorded in my list of 1890, I find to be plentiful in twenty fathoms among shells and stones covered with *Bugula*.

Cylichna truncata has been met with several times, but its real locality is yet to be discovered.

Young specimens of *Oscanius membranaceus* were dredged repeatedly in the Sound during September, and on the night of the 21st were found actively swimming in some numbers at the surface of the sea.

Six additional specimens of *Lomanotus* were dredged within the Sound during June and September, but as yet no large individuals have been met with.

Cratena amœna and *olivacea* have been obtained rather often, and the same remark applies to *Jorunna Johnstoni* and *Lamellidoris aspera*. *Calma glaucoides* was dredged on June 18th, and a beautiful specimen of *Idalina elegans*, grotesquely embedded within a small *Cynthia* upon which it had been feeding, on July 30th. Mr. Gamble twice brought me specimens of a little Æolid, which proved upon examination to be the *Embletonia pulchra* of Alder and Hancock, although much paler in coloration than the type of that species. *Amphorina cœrulea*, a species which has not been met with on the English coasts since the time of Montagu, was dredged on September 12th. The individual captured was 3 mm. in length, and the whole of the body with the head and tentacles was of a semi-transparent pale greenish colour. The gorgeous cerata are the chief peculiarities of this little creature. The colour of these is partly due to the cæca shining through, and to the superficial markings of the skin. The cæca in this case were deep sage-green, granulated, nearly filling the cerata. The upper half of each ceras was marked by conspicuous bands of colour—a rather broad band of glistening dots of cerulean blue, bounded above and below by a ring of bright yellow pigment-cells, branched and reticulating. There was no trace of orange. The rhinophores were rather short and conical, not filiform, as Vayssière found to be the case at Marseilles ('Ann. Mus. Hist. Nat. Marseille,' t. iii, mem. 4, pl. i, fig. 5), nor nearly so long as represented in his figure, perhaps because they were incompletely extended. They were held vertically upwards, parallel with each other; while the oral tentacles, slightly dilated towards their extremities, were held horizontally, and curved outwards on each side. There were seven rows of stout clavate cerata (2×2, 3, 4, 3, 2, 2, 1). The first three rows were close together, forming a cluster as in *Cratena*; this was separated from the fourth row, and the posterior rows from one another, by a considerable interval.

In August two specimens of *Antiopa hyalina* were dredged, one

of them 5·5 mm., the other 9·5 mm. in length. This rare species furnishes another valuable addition to our fauna.

Perhaps the most interesting addition of all, however, has been the rediscovery of D'Orbigny's *Stiliger bellula*, the *Calliopæa bellula* of that author's beautiful memoir on new species and genera of Nudibranchs observed on the coast of France. Ten individuals were dredged in Cawsand Bay on the 3rd of August, but I have hardly a remark to add to the admirable description of the external form, colour, and habits of the species which the talented French naturalist gave sixty years ago. The bearings of the anatomy of this primitive form upon the epipodial theory of the cerata must be important, since it occupies a position intermediate between *Hermæa* and the Æolids, which have been shown by Prof. Herdman to possess a ceratal innervation constructed upon two distinct types.

Among Cephalopoda, *Eledone cirrhosa* and *Sepiola atlantica* are plentiful; *Rossia macrosoma* has been taken twice this autumn. The smallness and unseaworthiness of our present steamboat unfortunately prevent us from visiting the proper localities for the larger species of cuttle-fish, and we are therefore unable to obtain good specimens of forms like *Loligo Forbesii* except on rare occasions.

CRUSTACEA.—An Amphipod, which Dr. Norman has kindly identified for me as *Unciola crenatipalma*, Bate (sp.), is plentiful among shells and stones on a muddy bottom at a depth of twenty fathoms. The two sexes were described by Spence Bate under the names *Dryope crenatipalma* (♀) and *D. irrorata* (♂), and wrongly removed by him from the genus *Unciola*, to which Gosse had rightly referred the latter "species," owing to his inability to discover the secondary appendage of the first antennæ. A minute one-jointed appendage, however, is constantly present, as Stebbing has already stated. The species is readily recognised, when alive, by its form and colour, the latter being yellowish, much speckled with white. It appears to be very locally distributed, for it is not included in Mr. David Robertson's recent catalogue, in Mr. A. O. Walker's lists of the L. M. B. C. Amphipoda, or in Carus's Prodromus Faunæ Mediterraneæ.

Corophium grossipes (*longicorne*) and *C. crassicorne* (*Bonellii*) inhabit their special localities in thousands.

Among Isopoda, *Apseudes talpa* has been taken in some numbers, while species of *Anceus*, *Munna*, and *Jæra* are abundant. On June 19th I found a male *Anthura gracilis*, 4 mm. long, provided with an antennal flagellum of nine joints, each of which was encircled by a dense ring of long slender hairs. Another specimen, dredged on September 16th, was 5 mm. long; the antennæ were as long as the head and first two segments of the pereion, and each of the twelve joints of the flagella was encircled with hairs, as in the preceding

specimen. The discovery of these specimens confirms in an interesting manner the prediction of Norman and Stebbing concerning the secondary sexual characters of the adult male of this species (Trans. Zool. Soc., xii, p. 123).

A specimen of *Idotea parallela* (B. and W.) was dredged on June 8th in Cawsand Bay. It presented a curious appearance when alive, for it was inhabiting a piece of the stem of a dead *Zostera* plant, which it carried about with it like a caddis-worm in its tube. The thick, soft, white antennæ of this species are very characteristic, and were at first much more suggestive to me of the tentacles of a Polychæte than of Crustacean appendages.

Two species of *Arcturus* have been frequently taken among the filamentous Algæ to which they cling. Their peculiar form, colour, and habits of fixation render them excellent examples of protective adaptation.

The Cumacea are still under examination. *Pseudocuma cercaria* is abundant; and *Iphinoë trispinosa*, a species of *Diastylis*, and other forms, are plentiful in their respective localities.

Of the Schizopoda, *Macromysis flexuosa* (*chamæleon* of authors) has been very abundant this summer. Each time that I visited the estuary of the Yealm during July and August I found it at low tide swimming in countless myriads close to the water's edge. It is interesting to watch the behaviour of this Mysis when placed in a tank containing some of its piscine enemies. It is a good match for the sharp-sighted but too eager wrasses, and, when pursued, generally manages to escape from them by darting swiftly away in an irregular zigzag manner; but the John Dory catches the Mysis easily by moving stealthily towards them by means of its almost invisible fins, and, when within reach, suddenly projecting its huge protrusible jaws, and sucking in the unsuspicious shrimps. The middle of July marked the height of the breeding season of this species.

The same may be said of *Schistomysis spiritus*, which was taken in considerable numbers in Whitsand Bay on July 15th, at which date all the individuals were of large size, and the marsupial pouches of the females were full of embryos. By August 3rd almost all the large individuals had disappeared, and the bottom net brought up thousands of small Schizopods, consisting chiefly of the young of this species. Along with them, however, were adult specimens of *Gastrosaccus sanctus*, and of a small robust species of *Schistomysis*, allied to *S. arenosa*, which seems to be new to science.

On the night of September 21st the Mysidæ *Gastrosaccus Normani* and *Siriella jaltensis* (*S. crassipes*, G. O. Sars) were taken in the surface-net in about equal numbers (principally males). The former species was taken by the "Porcupine" in 1869, and by

Norman off the south-west coast of Ireland in the following year, since which date it appears not to have been observed upon our coasts.

Our museum already contains a considerable collection of Decapoda, named by Prof. Weldon and Dr. Norman, which is all but representative of the fauna. The year's additions to this type collection consist of the species *Xantho floridus, rivulosus,* and *tuberculatus, Hyas araneus, Achæus Cranchii* (a valuable addition made by my assistant, Mr. Walker, in the spring), and *Eupagurus Forbesii,* which was added by Mr. Riches. The reserve stores of other interesting forms, *e. g. Portunus arcuatus, Polybius Henslowii, Ebalia, Diogenes varians, Crangon Allmanni,* have been considerably increased.

Notes on the Plankton observed at Plymouth during June, July, August and September, 1892.

By

Edward J. Bles, B.Sc.,
Hon. Research Fellow in the Owens College.

THE absence of systematic records showing the variations of the floating fauna and flora, or plankton, of the Plymouth waters is much to be regretted. My observations on the amount of animal and plant life suspended in the sea from the surface to the bottom would show that in comparison with similar observations made elsewhere, the quantity of plankton in this locality was during the past summer surprisingly small. The absence of data upon which comparisons could be based between the state of the water in this season and that obtaining in former years is all the more to be deplored because the present season has in many respects been a remarkable one. In the first place, the Plymouth mackerel fishery has so far been a complete failure; it has further been found that dog-fishes (both *Scyllium* and *Acanthias*) were not obtainable during June and July; and lastly, *Aurelia aurita,* which in summer is usually common, was extremely scarce in the Sound and tidal waters of Plymouth. If my surmise that the amount of plankton was for the locality exceptionally small proves correct, then these three salient instances of scarcity of animals which are directly or indirectly dependent on the plankton for their food will suffice to show the importance of a series of more or less continuous observations on the physical and biological condition of the inshore and Channel waters. Were accurate information on these points available, it would in all probability enable us to explain, and we might even in time be able to foresee, the occurrence of so important an event as the exceptionally sporadic appearance of the mackerel in 1892.

The quantitative and faunistic observations I have made with the aid of a Royal Society grant are made with this object in view, but it will be some time before the results are ready for publication, and it may now be of interest to record some extracts from my diary.

June 17th.—**Hormiphora plumosa,** the Ctenophore common at

Plymouth, was not seen in the adult condition after this date, but at the middle of September minute young Hormiphora made their appearance and ova were found, but the adult was absent from hauls which otherwise were in excellent condition.

The Hydroid medusa, **Obelia lucifera**, was very plentiful throughout June. It was interesting to note the effect of killing the medusæ in the dark. On adding a saturated solution of corrosive sublimate to the sea water the stimulus caused the animals to become phosphorescent, and the position of each medusa was indicated by a small clear ring of blue light round the margin of the umbrella. The light did not fade until after about a minute.

June 21st.—From this day onwards **Porcellana zoœa** have occurred almost constantly. On *June 28th* **Appendicularia** were first observed, and on *July 4th* they became very common, chiefly belonging to the species Oikopleura cophocerca. Of this form young specimens abounded.

Rhizoselenia obtusa and R. setigera, two diatoms with immensely elongated frustules, began to occur in large numbers on July 4th. On this day, moreover, **Evadne** appeared, together with the other marine Cladoceran **Podon** which hitherto had been the only representative of the group. Evadne gradually increased in numbers, while Podon gradually became scarcer, disappearing near the middle of September. Evadne constantly produced swarms of ephippial young, and is still bearing ova and larvæ (1st October), but about the middle of September they commenced to produce their large winter eggs, one egg in each individual. Another feature of the haul on July 4th was the great increase in the quantity of **Dinoflagellates**, Ceratium tripos, C. fusus, and Peridinium sp. Both the Dinoflagellates and Rhizoselenia are known to be more abundant towards the south-west and near the ocean, and on June 25th I found Evadne in large numbers off the French coast, sixty to seventy miles south of Plymouth.

The sudden appearance on July 4th of these various forms from the south and south-west may perhaps be explained. On June 28th the wind in the western part of the channel was light and variable, but from then until July 3rd—4th it blew from a westerly quarter (S.W. and W.S.W.), freshening on July 3rd. These facts seem to indicate that the wind has a very marked influence on the distribution of plankton. This conclusion is strongly supported by the fact that oceanic **Radiolaria** belonging to Haeckel's Acantharia also occur in the same haul of July 4th. Mr. Bourne, in his Report of a Cruise in H.M.S. "Research" off the South-west Coast of Ireland, remarks, "The absence of pelagic Radiolaria at Plymouth has often engaged my attention,"* and records the

* This Journal, vol. i, p. 321.

occurrence of several species in "tolerable abundance" amongst them an Acanthometron, which may be identical with mine. On no other occasion have I seen Radiolaria at Plymouth, and this sudden appearance, together with that of the other organisms mentioned, very probably indicates that the surface-layers of the sea with their plankton are displaced through considerable distances by the prolonged or powerful action of the wind in one direction.* It is desirable that this observation should be extended and confirmed, as it has obviously an important bearing on the distribution of the food of migratory fishes like the herring and mackerel.

July 23rd.—**Saphenia mirabilis**, *Haeckel*, was taken at the bottom in 9 fathoms off Penlee Point. The specimens were of the same size as those recorded by Mr. J. T. Cunningham in this Journal, vol. ii, page 194. The haul also contained a number of **Irene viridula**, *Eschsch.*, a medusa which was almost invariably present in the bottom tow-nettings from June to August. Once only did they appear in a surface netting, and that was one taken soon after midnight on July 21st in Start Bay.

August 26th.—The Siphonophore **Muggiæa atlantica**, *Cunningham*, made its appearance. The eudoxomes were at this time immature, and were not observed to be detached until September 2nd, when they bore ripe sexual products in the manubrium of the genital nectocalyx. Later on (23rd September) I found the young Calyconula larva corresponding to a figure by Chun in the Ann. and Mag. Nat. Hist., ser. 5, vol. xi, pl. v, fig. 6. This was at a time when the adult occurred in very large numbers, and just before it began to become scarce.

September 5th.—The pelagic larva of the interesting Polychæte, **Magelona papillicornis**, *Fr. Müll.*, was plentiful for a fortnight after this date, and then began to diminish in numbers ; at the end of the month only stray specimens were found.

September 10th.—Young **Amphioxus** larvæ were taken just outside the Breakwater. A few more at a slightly later stage were taken on 13th and 17th September, with sixteen to seventeen primary gill-slits.

September 23rd.—**Müller's larva** (Polyclad) was first noticed and was frequently found during the ensuing week. In August and September the surface tow-nettings often contained a young Polyclad, probably **Leptoplana**, from 1½ to 2 mm. in length.

September 24th.—The absence of **Noctiluca** is a very extraordinary feature of the year, for 1891 was remarkable for the immense pro-

* Dr. John Murray informed me that Radiolarians had not been taken in the Clyde area until I found them, after the prolonged south-westerly gales of 24th to 26th August, in a tow-netting taken from the yacht "Medusa," off Rothesay, Bute.

fusion of this infusorian, which in the months of June and July was present in such numbers that it discoloured large stretches of sea. This year it has been almost entirely absent, and a few individuals which I found at the end of September were the only signs of its existence. There were no great displays of phosphorescence this summer, either in the Sound or in the Channel, on the occasion of my nocturnal excursions.

September 30th.—Two species of Copepods which, according to Bourne (this Journal, vol. i, pp. 150 and 151) have only been taken here from February to May, I found outside the Breakwater in September. They are **Euterpe gracilis** and **Corycæus anglicus**, the former being fairly plentiful. During the whole summer **Cetochilus septentrionalis** has been present, but never in large numbers, each tow-netting generally containing a few.

In the last days of September a marked increase in the number of **Dinoflagellates** took place, and among them a form appeared which seems to be intermediate between Dinophysis and Ornithocercus, but which I have not yet identified.

I have collected a number of interesting Annelid and Mollusc larvæ, which I have not mentioned above, as I hope to report on them in detail elsewhere.

I have found that it is easy to rear Annelid and other larvæ by the following method :—The whole of a tow-netting in a large confectionery jar full of pure sea-water may be placed up to its neck in a tank through which water circulates. If the tow-netting is rich in species but poor in individuals, a large number of larvæ will live and continue to develope. Such a tow-netting I obtained on September 5th, and in seven to ten days later, after keeping the bottle at a constant low temperature in the way described above, I found on the sides of the bottle young Serpulids in tubes, a few two- three- aud four-celled colonies of Membranipora and young bivalve molluscs in the prodissoconch stage. I also found four specimens of *Protodrilus leuckartii, Hatschek,* a most interesting Archiannelid which has until now, I believe, not been recorded from any other locality but the Mediterranean and Black Sea.

Report on the Probable Ages of Young Fish collected by Mr. Holt in the North Sea.

By

J. T. Cunningham, M.A.

During the past summer Mr. Holt has sent me from time to time young specimens of fish which he has collected, in order that I might report upon the evidence which they afforded as to the rate of growth of the various species in the North Sea. He has also supplied me with a complete list containing the names and the measurements of all the specimens he has collected, including many others besides those sent to me. I have simply studied the specimens and the list, and endeavoured to estimate the probable ages of the specimens. The necessary information as to the limits and duration of the spawning period in the case of each species has also been supplied to me by Mr. Holt. I have registered below the observed specimens of each species separately in the chronological order of their capture. All have been collected in the course of the current year.

The principal sources whence these specimens were obtained were the shrimp nets worked on the sands at Cleethorpes, the shrimp-trawls in the Humber, Grimsby Market, and the deep sea trawling grounds. The shrimp-nets are of two kinds—the shove-net worked by hand, the fisherman wading in the water ; and the cart-trawl,* which is drawn by a horse. The shove-net is ten feet wide at the lower end, the cart-trawl is larger. In Mr. Holt's list there are records of fish taken in these nets at the end of April, in May, in June, in July, and in September. The fish obtained from them were most numerous at the end of April, when they consisted of hundreds of small plaice, with a few flounders, dabs, soles, turbots, brill, and smelt. With these were numerous valueless fish, such as gobies and dragonets, which need not here be considered. The majority of the small plaice were $1\frac{1}{2}$ to 3 inches long, and I think there is little doubt that they were derived from the same year's spawning, which commenced in January. None of the other

* Locally termed a "shrimp-seine" (*vide* p. 387).

valuable fish from these nets in April were so young, all being in their second year at least. In May the same kinds of fish were obtained, but the plaice were not so numerous; in addition to those mentioned, two whiting occurred, about eleven months old, 4 and 5½ inches long. In June also plaice of the year occurred in large numbers, over 200 on the 3rd in the cart-trawl. A few soles, flounders, plaice, turbot, brill, one year old, continued to be taken. In July the year's plaice are in much smaller numbers, 25 on one occasion, 13 on another. Soles and brill 3 to 7 inches long still occurred. On September 10th plaice of the year were still present, but in small numbers, only 40 under 3 inches being taken; on this date one whiting 3¾ inches long, and hatched the preceding spring, was taken.

If we turn next to the fish taken by the fish- and shrimp-trawls in the Humber at a depth of 1 to 2 fathoms, we find in March plaice 5 to 9 inches long the most numerous; the majority of these are one year old, some may be two years; there are also a few year-old dabs, 1¼ to 3¼ inches; a year-old sole, 5¾ inches, and five specimens of year-old whiting, 4¾ to 6 inches. In May a considerable number of soles 7 to 10 inches long were taken, some of these are only one year old, but many of the larger are probably two years. There are also a large number of flounders 5 to 10 inches, and some larger, and plaice of the same sizes. Most of the flounders are two years old and upwards, and many of them adult and mature. The greater number of the plaice are 7 to 8 inches long, and these are probably only one year old. In June a large number of soles occur, of various sizes, from 7 to 12 inches; the smaller of these may be only one year old, the majority are two years, and some are probably adult. In July there occur only a few soles on one occasion, 5 to 7 inches long, one year old. In August there are no observations. September is remarkable for the appearance of large numbers of whiting 2½ to 5 inches long, and evidently derived from eggs shed in the preceding spring; 254 were taken on the 9th; cod of similar size occur, but in much smaller numbers. On the 9th half a dozen of the year's plaice were also taken.

These observations give a distinct and accurate idea of the destruction of young fish by shrimp fishing at the mouth of the Humber. The young fry of the year are largely taken in the case of two species only, the plaice and the whiting, the former at the very edge of the water by the shove-net and cart-trawl, the latter by the shrimp-trawl. These results, of course, only hold good for the months mentioned, the observations not extending beyond September. A considerable number of year-old, and therefore im-

mature specimens, are taken of the sole, plaice, turbot, and brill by the shove-nets, and they are also taken mixed with older specimens, some of which are mature, by the shrimp-trawls. Mr. Holt writes to me that spent soles begin to appear in the Humber about the beginning of July, and become numerous afterwards; that before July there are none but immature soles, with the occasional exception of a large fish which has not yet spawned. It must be remembered that, according to my observations in the flounder, only a minority of fish are mature at two years old. It is especially noteworthy that not a single lemon sole (*Pleuronectes microcephalus*) was taken in the shrimp-nets in the Humber.

The specimens in the list, which were obtained on the deep-sea trawling ground, are few in number. The most interesting are small cod, whiting, and haddock taken in July and August. These are from 2 to 5 inches long, and evidently derived from the year's spawning. The haddock were taken at thirty fathoms on the Great Fisher Bank, and also fifty to sixty miles to the eastward of Spurn Light-vessel at twenty fathoms, but most abundantly on the latter ground where eight occurred on one occasion, thirty-one on another. The young cod were most numerous on the Great Fisher Bank, where whiting did not occur at all; eight of the latter occurred in the other region mentioned. This shows that the whiting fry of the year are not confined to inshore waters, while the haddock fry seem to be absent from the latter entirely.

Of the fish obtained in Grimsby Market the smallest sole was 8 inches long, many were only 9 or 10 inches, but the majority were over 10 inches. Those about 8 inches long may have been only one year old, but the rest were probably two years or more. Plaice from the market were examined in May and June, and large numbers were obtained between 6 and 12 inches in length, those between 8 and 10 inches being most numerous. According to Mr. Holt all these were immature, but a male plaice was observed once to be ripe at 6¼ inches. Some plaice may reach 12 inches in one year, but probably only a small proportion, so that these small plaice from the market may be considered as mixed, some one year and some two years old. The only other fish in the list taken from the market were 140 turbot 11 to 15 inches long. Most of these were probably two years old or more, though some turbot may reach 12 inches in a year.

Pleuronectes platessa, the Plaice.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
Jan. 29	7	4·5—5·4	1¾—2⅛	8 or 9 months	Humberstone Sands, near Cleethorpes; sprat stake-nets.
	7	9·5—19·1	3¾—7½	9 to 12 "	
Feb. 20	1	15·9	6¼	2 years (ripe male)	35 miles E. of Flamborough Head, 33 fathoms; deep-sea trawler.
March 30	1	8·9	3½	12 to 14 months	Humber, North Channel, 1 to 2 fathoms.
	6	10·2—12·1	4—4¾	"	
	11	12·7—14·6	5—5¾	"	
	12	15·2—17·2	6—6¾	"	
	16	17·8—19·7	7—7¾	"	
	17	20·3—22·2	8—8¾	"	
	7	22·8—24·7	9—9¾	2 years	
	1	25·3	10	"	
	2	27·9	11	"	
April 25	5	3·8	1½	2 to 3 months	Cleethorpes to Humberstone Sands, spring tides; shrimp shove-net.
	149	4·4	1¾	"	
	240	5·1	2	"	
	176	5·7	2¼	3 to 4 months	
	72	6·3	2½	"	
	27	7·0	2¾	"	
	13	7·6	3	"	
	4	8·3	3¼	About 1 year	
	3	8·9	3½	"	
	3	9·5	3¾	"	
	4	10·2	4	"	
	204	4·4—10·8	1¾—4¼	Smaller 2—4 months	
	1	11·5	4½	1 year	
	3	12·7—15·2	5—6	"	
	1	18·4	7¼	"	
	Many	22·9 circâ	9 circâ	1 year or 2	
April 28	172	4·1—7·9	1⅝—3⅛	2 to 4 months	Cleethorpes Sands; shrimp shove-net.
	16	8·6—10·8	3⅜—4¼	About 1 year	
	1	12·0	4¾	"	
	4	15·2—20·3	6—8	"	
May 10–11	1	4·6	1 13/16	2 to 3 months	Cleethorpes Sands; shrimp shove-net, at night.
	2	5·0	2	"	
	3	5·4	2⅛	"	
	22	5·7—7·0	2¼—2¾	"	
	10	7·6	3	3 to 4 months	
	4	8·2	3¼	"	
	6	8·9	3½	"	
	7	9·5—12·0	3¾—4¾	About 1 year	
	8	12·7—15·2	5—6	"	
May 16	9	21·5	8½	1 year 4 months	Grimsby Market, from Arlberg, Denmark; 84 males and 114 females, all immature, contents of one box; fish much the same size in all boxes.
	37	22·8	9	"	
	51	24·1	9½	"	
	43	25·3	10	"	
	18	26·6	10½	"	
	11	27·9	11	"	
	6	29·2	11½	"	
	11	30·5	12	"	
	7	31·7	12½	"	

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
May 20	7	15·2	6	13 to 16 months	Tetney, mouth of the Humber; shrimp trawler.
	44	16·5	$6\frac{1}{2}$	,,	
	92	17·8	7	,,	
	81	19·0	$7\frac{1}{2}$	,,	
	92	20·3	8	,,	
	52	21·6	$8\frac{1}{2}$	,,	
	34	22·8	9	,,	
	15	24·1	$9\frac{1}{2}$	,,	
	8	25·3—27·9	10—11	,,	
May 24	2	12·7—15·2	5—6	13 to 16 months	Humber; shrimp trawler.
	27	17·8	7	,,	
	90	20·3	8	,,	
	67	22·8	9	,,	
	42	25·3	10	,,	
	6	27·9	11	,,	
May 28	2	12·7—13·9	5, $5\frac{1}{2}$	13 to 16 months	Cleethorpes Sands; shove-net.
	3	15·2—22·8	6—9	,,	
	1	24·1	$9\frac{1}{2}$	,,	
June 1	10	4·7—7·0	$1\frac{7}{8}$—$2\frac{3}{4}$	3 months	Cleethorpes; cart-trawl.
	1	16·2	$6\frac{3}{8}$	14 ,,	
June 1	1	15·2	6	14 to 18 months	Grimsby Market, from Schiermonnikoog; contents of one box, 154 males and 154 females, all immature except 2 males.
	8	17·8	7	,,	
	71	20·3	8	,,	
	120	22·8	9	,,	
	76	25·3	10	,,	
	5	27·9	11	Perhaps over 2 years	
	4	30·5	12	,,	
	1	33·0	13	,,	
June 3	235	4·1—7·9	$1\frac{5}{8}$—$3\frac{1}{8}$	3 or 4 months	Cleethorpes to Humberstone; cart-trawl.
	3	8·9—10·5	$3\frac{1}{2}$—$4\frac{1}{8}$	6 months	
	2	10·2	4	,,	
	15	12·7	5	,,	
	35	15·2	6	Over 1 year	
	17	17·8	7	,,	
	8	20·3	8	,,	
	1	23·2	$9\frac{1}{8}$	,,	
July 19	25	2·1—4·4	$1\frac{1}{16}$—$1\frac{3}{4}$	3 months	Cleethorpes Sands; shove-net.
July 22	13	2·5—3·3	1—$1\frac{5}{16}$	,,	
Sept. 9	5	3·9—4·6	$1\frac{9}{16}$—$1\frac{13}{16}$	5 months	Off Humberstone; shrimp-trawl.
Sept. 10	38	3·6—4·9	$1\frac{7}{16}$—$1\frac{15}{16}$	5 or 6 months	Cleethorpes to Humberstone; shrimp shove-net; low tide just after springs.
	3	5·5—7·0	$2\frac{3}{16}$—$2\frac{3}{4}$	7 months	
	1	12·7	5	8 ,,	

It will be seen from the above record that there was a great outburst, so to speak, of small plaice at the end of April. On April 25th several hundred were taken in the shove-net, on the 28th nearly 200. The greatest number of these were 2 inches in length, their range in length was from $1\frac{1}{2}$ to 3 inches; the specimens ex-

ceeding 3 inches were comparatively few in number. In May only a few specimens of this size were taken. They appear only on one day (or night), May 10th—11th, the number is less than fifty; the average size of these is a little larger, the greatest number being from $2\frac{1}{4}$ to $2\frac{3}{4}$. At the beginning of June another outburst appears; on the 1st only a few are taken, but on the 3rd 235 are taken in the cart-trawl. In July, in the middle of the month a few still smaller specimens are taken, only about $1\frac{1}{2}$ inches long, and as late as the beginning of September we find thirty-eight specimens under 2 inches long in the shove-net. Mr. Holt finds that plaice spawn in the North Sea chiefly from the middle of January to the end of March, though a few may spawn earlier or later. I think it is evident that the large number of specimens 2 inches in length taken at the end of April are derived from the eggs shed in January, and are therefore three months old. Those which are larger may be a week or two older or may have grown faster. I have shown in previous papers how variable the rate of growth is. Those which are smaller than 2 inches, may in like manner be younger, or may have grown more slowly. It is difficult to fix the maximum size of specimens derived from the immediately preceding spawning season. I have fixed it at 3 inches, referring specimens above this length to the spawning of the previous year. I do not understand why comparatively few of these young plaice were taken in May. The large number taken at the beginning of June include chiefly those hatched in February and March. Those taken in July and September are few in number, and represent those whose growth has been slow, who have been behindhand in the competition for food, or which are the progeny of the last spawners of the season, of parents which spawned in April or even in May. All these young plaice of the year are taken on the flat sandy shores near Grimsby in shrimp nets, either in the shove-net, which is worked by hand, and has a spread of 10 feet, or by the cart trawl which is towed by a horse. I have shown previously (this Journal, vol. ii, No. 2, p. 99), that plaice of the year occur in June on similar sandy shores near Plymouth. It is evident that the destruction or, at any rate, the capture of plaice fry by shrimpers at the mouth of the Humber must be enormous.

I have considered the seven specimens taken in sprat stake-nets on January 29th to be remnants of the previous year's brood. Possibly some plaice may spawn in December, but even then the young fish produced could not reach a length of two inches in less than two months. These small fish must, therefore, be derived from the spawning of the previous year, and be eight or nine months old *at least*. The consideration of such specimens as these shows conclu-

sively that fish may live in the sea for months, with scarcely any increase in size, just as some of the flounders out of a number kept by me in captivity. Some of my captive flounders were only about 2 inches in length when one year old; these plaice taken at Humberstone in January were of the same length, and must have been at least eight months old, while they may have been more.

It is not easy to infer from the data given in the table, the average size or the limits of growth of the plaice in their second year. In the entry for May 20th we have a large number of specimens certainly over a year old, and the greater number of these are $6\frac{1}{2}$ to $8\frac{1}{2}$ inches long. The flounders I reared in captivity were mostly from 4 to 6 inches long at one year of age, and as the plaice in the North Sea is a much larger fish, and these were taken some months after the principal spawning season, these specimens may all have been in their second year only. But on the other hand, it is certain that some fish at two years old are not bigger than others at one year, so that it is impossible to say whether some fish in their third year may not be present in this lot.

The maximum growth for a plaice of fourteen to sixteen months old is difficult to fix with the evidence at present available. The maximum observed by me in the flounder at one year was $7\frac{1}{2}$ inches, and as the plaice in the North Sea reaches 28 inches in length, while the flounder's maximum length is 16 or 17 inches, individual plaice might reach $12\frac{1}{2}$ inches in sixteen months. I have accordingly estimated the age of the specimens of May 16th from the Denmark coast at twelve to sixteen months; a conclusion supported by the fact that they were all immature. But some of these specimens may be in their third year.

It will be seen from the entry of March 30th, of fish taken in the Humber by a shrimp trawler, that many plaice occur, only 4, 5, or 6 inches long, which are certainly a year old.

Pleuronectes flesus, the Flounder.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
April 25	3	6·3—8·4	$2\frac{1}{2}$—$3\frac{5}{16}$	1 year	Cleethorpes to Humberstone Sands; shrimp shove-net.
	3	11·4—12·4	$4\frac{1}{2}$—$4\frac{7}{8}$	,,	
	1	23·5	$9\frac{1}{4}$	2 or 3 years	
	Several	About 22·8	About 9	,,	
April 28	4	5·9—9·1	$2\frac{5}{16}$—$3\frac{5}{8}$	1 year	Cleethorpes Sands; shove-net.
	2	10·8, 15·9	$4\frac{1}{4}$, $6\frac{1}{4}$	,,	
May 14	2	9·5, 12·5	$3\frac{3}{4}$, $4\frac{7}{8}$	1 year	Humberstone Sands; cart-trawl.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
May 20	1	12·7	5	1 year	Tetney, mouth of Humber; shrimp trawler.
	2	19·0	7½	"	
	9	20·3	8	2 years	
	8	22·9	9	"	
	3	24·1	9½	"	
	3	25·4	10	"	
	1	28·0	11	3 years	
	1	33·0	13	"	
May 24	1	16·5	6½	1 year	Humber; shrimp trawler.
	1	19·0	7½	"	
	1	20·3	8	2 years	
	2	22·9	9	"	
	1	24·8	9¾	"	
	2	25·4	10	"	
	1	30·5	12	3 years	
June 1	1	7·0	2¾	1 year	Cleethorpes Sands; cart-trawl.
June 3	2	8·9, 12·0	3½, 7½	"	

It will be seen from the table, that Mr. Holt has not obtained the young flounders of the year. The flounder spawns in the North Sea from February to the end of May, probably in March and April chiefly; there is thus no difference between the periods at Grimsby and at Plymouth, except that at Plymouth it begins and ends a few weeks earlier. The newly metamorphosed flounders appear at Mevagissey in the beginning of May or end of April, and are then only about ½ inch long.

I should think that the shove-net is as well adapted to catch small flounders as small plaice, and there must be plenty of flounders of the year's brood somewhere in the neighbourhood of Grimsby in June and July. Probably the reason that they are absent from these collections is that they ascend the rivers, and are, therefore, not to be found at the mouth of the estuary with the plaice.

Pleuronectes limanda, the Dab.

Date of collection.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
Feb. 20	1	12·1	4¾	1 year, ♀ immature	35 miles E. of Flamborough Head, 33 fathoms.
	6	12·3—15·6	5¼—6⅛	2 years, ripe	
	5	16·8—20·3	6⅝—8	"	
March 3	3	16·5—17·1	6½—6¾	2 years	45 miles E.N.E. of Spurn Light-vessel, 33 fathoms.
	26	17·8—20·3	7—8	"	
	6	20·6—21·3	8⅛—8⅜	3 years	
	1	20·4	10	"	

Date of collection.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
March 30	1	2·0	$\frac{3}{4}$	6 weeks	North Channel, Humber, 1 to 2 fathoms.
	2	3·2	$1\frac{1}{4}$	10 months	
	3	3·8—5·1	$1\frac{1}{2}$—2	"	
	1	8·2	$3\frac{1}{4}$	1 year	
April 2	4	13·3—14·6	$5\frac{1}{4}$—$5\frac{3}{4}$	2 years	S.W. edge of Dogger, $12\frac{1}{2}$ to 33 fathoms.
	4	15·9—17·2	$6\frac{1}{4}$—$6\frac{3}{4}$	"	
	4	20·6—22·9	$8\frac{1}{8}$—9	3 years	
April 6	2	7·0—7·6	$2\frac{3}{4}$—3	1 year	W. edge of Dogger, 27 to 30 fathoms.
	1	14·0	$5\frac{1}{2}$	"	
	11	15·3—17·2	6—$6\frac{3}{4}$	2 years	
	20	17·8—19·7	7—$7\frac{3}{4}$	"	
	15	20·3—22·2	8—$8\frac{3}{4}$	3 years	
	1	24·1	$9\frac{1}{2}$	"	
April 25	3	3·3—4·4	$1\frac{1}{4}$—$1\frac{3}{4}$	1 year	Cleethorpes to Humberstone Sands; shrimp shove-net.
April 28	2	4·1—4·7	$1\frac{5}{8}$—$1\frac{7}{8}$	"	Cleethorpes Sands; shove-net.
May 10	5	4·1—5·0	$1\frac{5}{8}$—2	"	Ditto, by night.
	5	5·2—8·9	$2\frac{1}{16}$—$3\frac{1}{8}$	"	
May 14	2	4·8	$1\frac{7}{8}$	"	Humberstone Sands; cart-trawl.
July 12	7	5·7—9·5	$2\frac{1}{4}$—$2\frac{3}{4}$	1 year 3 months	Inner shoal water of Great Fisher Bank, 30 fathoms trawl amongst *Flustra foliacea.*
	1	33·0	13	4 years	

Mr. Holt tells me that the dab began to spawn at Grimsby in the middle of February, and continued till the end of May; March and April being the principal months. Taking this into consideration, I find that among all the specimens registered above only one could possibly be derived from the spawning of 1892, namely the specimen $\frac{3}{4}$ inch long, taken on March 30th. I do not think that a specimen, hatched towards the end of February, could reach a length of $1\frac{1}{4}$ inches by the end of March, and have, therefore, attributed the specimens of that size to the spawning of the previous year. The young dabs from the same year's spawning were not taken in the shore-nets in June and July together with the plaice. I have estimated the probable age of the larger specimens in accordance with the considerations discussed in a former paper (this Journal, vol. ii, No. 2, p. 101). The examination of these specimens confirms the conclusions I formed from those collected at Plymouth.

There is only one specimen of the lemon sole (*Pleuronectes microcephalus*) in the collection; it is $7\frac{1}{2}$ inches (19 cm.) long, taken on the south-west edge of the Dogger Bank in $12\frac{1}{2}$ to 33 fathoms on April 2nd. This specimen may have been one year old, but was more

probably two years. Three specimens of the long rough dab (*Hippoglossoides limandoides*) were taken, two on April 4th, $4\frac{1}{16}$, $4\frac{5}{8}$ inches long (10·3, 11·8 cm.) on the west edge of the Dogger, and one on July 12th, on the Great Fisher Bank, $5\frac{1}{2}$ inches long (14 cm.). These three were doubtless year-old fish. The limits of the spawning period were not observed, but some fish of this species were found to be spawning in March.

Solea vulgaris, the Sole.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
Feb. 9	3	27·3—30·2	$10\frac{3}{4}$—$11\frac{7}{8}$	3rd year	Grimsby Market, smallest procurable, probably from Silver Pits.
	2	30·5—32·0	12—$12\frac{5}{8}$	,,	
Feb. 10	8	22·8—29·8	9—$11\frac{3}{4}$	,,	
Feb. 11	4	25·1—29·2	$9\frac{7}{8}$—$11\frac{1}{2}$	,,	
	3	30·5—31·4	12—$12\frac{3}{8}$	,,	
Feb. 20	3	25·4—26·9	10—$10\frac{5}{8}$	,,	
	6	28·3—29·5	$11\frac{1}{8}$—$11\frac{5}{8}$	,,	
	2	31·1—31·7	$12\frac{1}{4}$—$12\frac{1}{2}$	,,	
Feb. ?	7	28·6—31·1	$11\frac{1}{4}$—$12\frac{1}{4}$	,,	
March 30	1	14·6	$5\frac{3}{4}$	8 to 10 months	Humber, North Channel, 1 to 2 fathoms.
April 25	4	6·0—8·6	$2\frac{3}{8}$—$3\frac{3}{8}$	9 to 12 months	Cleethorpes; shrimp shove-net.
April 28	1	8·9	$3\frac{1}{2}$	,,	
	1	20·3	8	1 year	Grimsby Market, smallest procurable.
	4	22·8—25·4	9—10	2 years	
	2	27·9	11	,,	
May 4	2	7·6, 9·5	3, $3\frac{3}{4}$	9 to 12 months	Cleethorpes Sands; shove-net.
May 10	2	6·5, 7·3	$2\frac{1}{2}$, $2\frac{7}{8}$	,,	
May 14	1	11·8	$4\frac{5}{8}$	,,	Humberstone Sands; cart-trawl.
May 16	9	22·8—24·1	9—$9\frac{1}{2}$	2 years	Grimsby Market, from Dutch coast, smallest procurable; nearly all males.
	29	25·4—26·6	10—$10\frac{1}{2}$	,,	
	4	27·9—29·2	11—$11\frac{1}{2}$	,,	
	2	20·3, 21·6	8, $8\frac{1}{2}$	,,	Humber; shrimp trawler; the whole catch sold, but smaller fish may have been eliminated at sea.
	4	22·8—24·1	9—$9\frac{1}{2}$	,,	
	1	38·1	15	3 years	
May 17	1	8·4	$3\frac{1}{4}$	$9\frac{1}{2}$ to $12\frac{1}{2}$ months	Cleethorpes Sands; shove-net.
May 19	2	17·8—19·0	7, $7\frac{1}{2}$	1 year	Humber; shrimp trawler; whole catch as brought to market.
	10	20·3—21·6	8—$8\frac{1}{2}$	2 years	
	16	22·8—24·1	9—$9\frac{1}{2}$	,,	
	2	25·4—26·6	10—$10\frac{1}{2}$	,,	
May 27	3	20·3	8	,,	
	15	21·6	$8\frac{1}{2}$	,,	
	9	22·8	9	,,	
	6	24·1	$9\frac{1}{2}$	,,	
	1	25·4	10	,,	
May 31	4	21·6	$8\frac{1}{2}$	,,	
	3	22·8	9	,,	
	3	24·1	$9\frac{1}{2}$	,,	
	2	25·4	10	,,	
	1	26·6	$10\frac{1}{2}$	,,	

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
June 1	2	9·2—15·2	$3\frac{5}{8}$, 6	10 to 13 months	Cleethorpes Sands; cart-trawl.
June 3	2	8·3, 8·7	$3\frac{1}{4}$, $3\frac{7}{16}$	"	Cleethorpes to Humberstone; cart-trawl.
June 15	4	21·6	$8\frac{1}{2}$	2 years	Humber; shrimp trawler.
	3	22·8	9	"	
	3	24·1	$9\frac{1}{2}$	"	
	2	25·4	10	"	
	1	26·6	$10\frac{1}{2}$	"	
June 17	2	17·2—17·5	$6\frac{3}{4}$—$6\frac{7}{8}$	1 year	
	10	18·1—20·3	$7\frac{1}{8}$—8	"	
	25	20·6—22·9	$8\frac{1}{8}$—9	2 years	
	10	23·5—24·4	$9\frac{1}{4}$—$9\frac{5}{8}$	"	
	5	25·4—26·0	10—$10\frac{1}{4}$	"	
	2	28·6—29·9	$11\frac{1}{4}$—$11\frac{3}{4}$	"	
	1	32·0	$12\frac{5}{8}$	3 years	
June 15	8	6·4—8·9	$2\frac{1}{2}$—$3\frac{1}{2}$	$10\frac{1}{2}$ to $13\frac{1}{2}$ months	Cleethorpes Sands; shove-net.
	1	22·9	9	2 years	Humberstone Sands; shove-net.
June 23	2	7·8, 11·3	$3\frac{1}{16}$, $4\frac{7}{16}$	11 to 14 months	New Clee; shove-net.
July 2	2	10·2, 19·1	4, $7\frac{1}{2}$	"	
July 14	3	12·7—15·2	5—6	1 year	Mouth of Humber, Tetney ground; shrimp trawler's whole catch for night; no fish returned to sea.
	9	16·5	$6\frac{1}{2}$	"	
	5	17·8	7	"	
July 15	2	16·8, 17·2	$6\frac{5}{8}$, $6\frac{3}{4}$	$11\frac{1}{2}$ to $14\frac{1}{2}$ months	Tetney Sands; shove-net.
July 20	1	9·8	$3\frac{7}{8}$	"	Cleethorpes Sands; shove-net.

The most interesting feature of this collection is the absence of soles small enough to be referred to the spawning season of the same year. Mr. Holt finds that in the North Sea the spawning period of the sole coincides with that of the brill, but that it is not quite over till the beginning of August. Therefore, it begins at the end of April, goes on chiefly in May and June, and rare individuals are found spawning in July. The smallest specimens obtained are $2\frac{3}{8}$ to $2\frac{1}{2}$ inches, 6·0 to 6·4 cm. long, and were taken in the shove-net on Cleethorpes sands in April, May, and June. These could not be less than nine or ten months old, and may have been more, so that some soles grow as slowly under natural conditions as some of the flounders which I have reared in captivity. These soles of the previous year's brood were taken chiefly in the shove-net or the cart-trawl quite close to the shore, very few appearing in the produce of the shrimp trawlers. The sole is somewhat larger than the flounder, and we may reasonably suppose that 8 inches is about the maximum length attained in one year's growth. The total number of specimens obtained which were less than 8 inches long is sixty-

two, of which thirty-five were taken in the shrimp trawl at some distance from shore, and twenty-seven in the shove-net in less than one fathom of water. But the smallest taken in the shrimp trawl is 5 inches long, and some of the specimens between 5 and 8 inches may be in their third year. We can scarcely suppose that these small numbers represent more than a small portion of the previous year's produce, so that one-year-old soles would seem to be by no means exclusively found in shallow waters near shore.

The young soles derived from the year's spawning might be expected to appear from June onwards, and to be at first from $\frac{1}{2}$ inch to $1\frac{1}{2}$ inches in length, later reaching 2 inches. But although plaice of about this size were taken in June, July, and September, no such soles appear. At Mevagissey I have found soles less than 1 inch long in May in small numbers in tide pools, so that it is certain they do occasionally come to the shore. Provisionally I infer from these facts that the soles of the year are widely distributed over the North Sea, and do not, like the plaice, collect together in the shallow waters near the shore.

There is no definite gap or interval between the series of sizes of the soles caught by the shrimp trawl in the Humber, and the series of those caught by the deep-sea trawl, and procured in Grimsby Market. The minimum size of the deep-sea specimens is larger, namely 8 inches, but soles of 8 to 12 inches and upwards are obtained both in the estuary and out at sea, both in the shrimp trawl and the great trawl. I have attempted to indicate the probable age of these specimens, taking 12 inches as about the maximum length, at two years of age; but, as I have before pointed out, the growth of fish is so variable in different individuals, that it is not possible to distinguish by size alone two-year-old specimens from those which are three years old or more.

Rhombus lævis, the Brill.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
April 25	2	9·1—9·6	$3\frac{5}{8}$—$3\frac{3}{4}$	9 to 11 months	Cleethorpes to Humberstone Sands; shrimp shove-net.
April 28	1	10·4	$4\frac{1}{16}$	"	Cleethorpes Sands; shrimp shove-net.
May 4	2	7·4—9·6	$2\frac{15}{16}$—3	10 to 12 months	" " "
May 14	2	9·8—10·8	$3\frac{7}{8}$—$4\frac{1}{4}$	"	Humberstone Sands; cart-trawl.
June 15	2	8·9—10·4	$3\frac{1}{2}$—$4\frac{1}{8}$	11 to 13 months	Humberstone Sands; shrimp shove-net.
July 20	1	13·9	$5\frac{1}{2}$	"	Cleethorpes; shove-net.

Mr. Holt finds that the brill begins to spawn in the latter part of April, and that some ripe fish are found until the end of July, the majority of the fish shedding their eggs in May and the early part of June. It is clear, therefore, that the specimens recorded in the table are all about a year old. In a previous paper (Journ. Marine Biol. Assoc., vol. ii, No. 2) I recorded the growth of young brill reared by me in captivity in 1890—91; some of them reached 2·8 to 3·9 inches in length in six months, others 3·3 to 3·7 inches in twelve months. It is interesting to find that the specimens collected by Mr. Holt from the sea were no larger at the end of their first year than those reared in the Plymouth aquarium. At the same time these year-old brill were taken only in small numbers in the shrimp-nets in the Humber, and cannot be considered as fully representing the young fish derived from the spawning of the previous year. Probably the year-old fish are widely distributed from the shore to deep water, and the average and the maximum sizes for fishes at that age are probably greater than those of the above specimens. The young brill of the year are pelagic in May and June, and could not be taken on the bottom till August and September and following months

Rhombus maximus, the Turbot.

Date of capture.	No. of specimens.	Length of centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
April 25	1	7·9	$3\frac{1}{8}$	8 to 11 months	Cleethorpes to Humberstone Sands; shrimp shove-net.
May 16	1	6·8	$2\frac{11}{16}$	9 to 12 months	Cleethorpes; seine.
May 16	2	7·3, 8·5	$2\frac{7}{8}$, $3\frac{3}{8}$	,,	Humberstone Sands; cart-trawl.
June 3	140	28·0—38·1	11—15	2 years	Grimsby Market; trawler from opposite coast; the whole catch of this species.
June 15	1	10·6	$4\frac{1}{8}$	10 to 13 months	Humberstone Sands; shrimp shove-net.
Taken in surface-net:					
July 1	1	·55	$\frac{3}{16}$	A few weeks	22 miles N.N.E. of Horn Light Vessel.
	12	·6—·9	$\frac{1}{2}$—$\frac{5}{8}$	,,	
July 12	1	·7	$\frac{1}{4}$	,,	Inner shoal of Great Fisher Bank; about 220 miles N.E. by E. of Spurn Light Vessel.
July 28	22	·7—1·3	$\frac{1}{4}$—$\frac{1}{2}$	,,	150 miles E. by N. of Spurn Light Vessel.
Aug. 10	6	·6—1·6	$\frac{1}{4}$—$\frac{5}{8}$	,,	Off the N.W. corner of the Dogger.

The spawning of the turbot in the North Sea, according to Mr. Holt, is general in June and July, but occasional ripe fish occur as early as the end of March and as late as the beginning of September.

In the above estimates of ages I have included, therefore, four spawning months—May, June, July, and August—leaving out April, when probably few turbot spawn. Those taken in shore waters in the shrimp-nets, like the young brill in the previous table, are undoubtedly from the spawning of the previous year, and probably represent only the most backward specimens of that year's brood. I have at present no evidence as to the average or the maximum length of year-old specimens; but as the maximum length of the turbot, according to Dr. Fulton, is 28 inches, I should think that most of those obtained in Grimsby Market on June 3rd, 11 to 15 inches long, were two years old, and some may have been three years.

Some observations on the growth of turbot in captivity were made many years ago in France, and are published in the *Bulletin de la Société Impériale Zoologique d'Acclimatation* for 16th June, 1865. At the aquarium of Concarneau young turbot hatched in June, 1864, had a length of 5 to 6 cm., 2 to $2\frac{3}{8}$ inches, on April 16th, 1865, and a mean weight of 4 grammes. Others, a little older, hatched in April, 1864, had on the same date a length of 14 to 19 cm., $5\frac{1}{2}$ to $7\frac{1}{2}$ inches, and weighed 52 to 126 grammes. Others about two years old measured 20 to 28 cm., $7\frac{7}{8}$ to 11 inches, and weighed 200 to 380 grammes. All these specimens had been taken by the seine on sandy shores, and how far the ages given are accurate I am unable to say. But the sizes given agree closely with my own conclusions. The authors call particular attention to the inequality in the rate of growth, and give the same explanation as I have given for my captive flounders, namely, that the most greedy and boldest individuals seize all the food.

Gadus morrhua, the Cod.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
July 12	Many	4·7—12·7	$1\frac{3}{4}$—5	3 to 6 months	Inner shoal-water of Great Fisher Bank, 30 fathoms, trawl, among *Flustra foliacea.*
Aug. 14	2	5·0, 6·3	2, $2\frac{1}{2}$	4 or 5 months	54 miles E. of Spurn Light Vessel; trawl, 20 fathoms.
Sept. 7	1	7·3	$2\frac{7}{8}$	5 or 6 months	Shrimp trawl, off Humberstone.
Sept. 9	13	6·0—7·3	$2\frac{3}{8}$—$2\frac{7}{8}$	,,	Shrimp trawl, off Humberstone.
	3	8·0—9·8	$3\frac{1}{8}$—$3\frac{7}{8}$	,,	Shrimp trawl, off Humberstone.

The cod spawns chiefly from the end of January to the end of April, and it is evident that these specimens belong to the year's produce. They seem to be widely distributed, having been taken

both on the Fisher Bank in the middle of the North Sea, and in the estuary of the Humber.

Gadus merlangus, the Whiting.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
Jan. 29	118	10·2—14·9	4—5$\frac{7}{8}$	9 months	Sprat stake-nets at Humberstone Sands.
	11	15·2—19	6—7$\frac{1}{2}$	11 months	
Feb. 20	2	17·1—21	6$\frac{3}{4}$—8$\frac{1}{4}$	11 months and 2 years	35 miles E. of Flamborough Head; 33 fathoms.
Mar. 3	1	14·6	5$\frac{3}{4}$	1 year	45 miles E.N.E. of Spurn Light Vessel; 33 fathoms.
Mar. 30	5	12·1—15·2	4$\frac{3}{4}$—6	,,	North Channel, Humber; 1 to 2 fathoms.
April 2	2	22·9—25·4	9—10	2 years	S.W. corner of Dogger; 20 to 26 fathoms.
April 2	Number	16·5	6$\frac{1}{2}$ upwards	1 and 2 years	S.W. edge of Dogger; 12$\frac{1}{2}$ to 33 fathoms.
April 2	,,	20·3	8 upwards	2 years	W. edge of Dogger; 20 to 33 fathoms.
May 10	2	10·2—14	4, 5$\frac{1}{2}$	11 months	Cleethorpe Sands; shrimp shove-net.
Aug. 8	1	8·3	3$\frac{1}{4}$	4 months	54 miles E. of Spurn Light Vessel; 20 fathoms.
Aug. 28	7	7·6—9·2	3—3$\frac{5}{8}$	,,	61 miles E. by S. of Spurn Light Vessel; 16 to 20 fathoms.
Sept. 7	44	7·3—11·1	2$\frac{7}{8}$—4$\frac{3}{8}$	3 to 6 months	Off Humberstone; shrimp trawl.
Sept. 9	254	6·7—12·6	2$\frac{5}{8}$—4$\frac{15}{16}$	,,	
Sept. 10	1	9·5	3$\frac{3}{4}$	,,	Cleethorpes to Humberstone; shove-net.

Mr. Holt finds that the whiting spawns in the North Sea from the beginning of March to the early part of June, chiefly in April. It is evident, therefore, that whiting taken on January 29th could not be less than eight months old. The specimens taken on this date are from 4 to 7$\frac{1}{2}$ inches long. The smaller, 4 to 5$\frac{7}{9}$ inches, might, I think, easily have reached that length if spawned the preceding April. The others, 6 to 7$\frac{1}{2}$ inches long, are more doubtful; the adult whiting does not exceed 16 inches in length, and some flounders, which are of the same size when full grown, reach 7$\frac{1}{2}$ inches in a year; I have, therefore, estimated the age of these whiting at eleven months. I do not think, however, that a whiting could reach 8$\frac{1}{4}$ inches in less than one year, and have put down the specimen of this size of February 20th as two years old. The whiting of the year appear, like the plaice, in large numbers in inshore waters, but later in the year; this is shown by the abundance of young specimens taken in the Humber at the beginning of September. They are not, however, entirely restricted to littoral zones, some having been taken in August in the middle of the North Sea.

Gadus æglefinus, the Haddock.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
Mar. 3	1	20·3	8	1 year	45 miles E.N.E. of Spurn Light Vessel; 33 fathoms.
April 2	Number	20·3 to 50·8	8 to 20	1 and 2 years and upwards	S.W. corner of Dogger; 20 to 26 fathoms.
April 2	Number	17·8 upwards	7 upwards	„	W. edge of Dogger; 20 to 33 fathoms.
May 20	1	16·5	$6\frac{1}{2}$	1 year	Grimsby Market.
	10	17·8—19·1	$7—7\frac{1}{2}$	„	
	17	20·3—21·6	$8—8\frac{1}{2}$	„	
	1	22·8	9	„	
	3	25·4—26·6	$10—10\frac{1}{2}$	2 years	
	2	28·0—29·2	$11—11\frac{1}{2}$	„	
July 12	2	5·7—8·9	$2\frac{1}{4}$, $3\frac{1}{2}$	4 or 5 months	Inner shoal water of Great Fisher Bank; 30 fathoms; trawl; amongst *Flustra foliacea.*
Aug. 14	1	8·1	$3\frac{3}{16}$	4 to 6 months	54 miles E. of Spurn Light Vessel; 20 fathoms; trawl.
	2	8·7, 8·9	$3\frac{7}{16}$, $3\frac{1}{2}$	„	
	2	9·8, 10·0	$3\frac{7}{8}$, $3\frac{15}{16}$	„	
	2	10·6, 10·8	$4\frac{3}{16}$, $4\frac{1}{4}$	„	
	1	12·1	$4\frac{3}{4}$	„	
Aug. 28	2	8·9, 9·1	$3\frac{1}{2}$, $3\frac{9}{16}$	4 to 6 months	61 miles E. by S. of Spurn Light Vessel; 16 to 20 fathoms; trawl.
	19	9·6—10·8	$3\frac{3}{4}—4\frac{1}{4}$	„	
	10	11·1—12·7	$4\frac{3}{8}—5$	„	

The haddock spawns in February, March, and April, especially in March. Young specimens derived from the year's spawning were taken on three occasions, once in July, twice in August. The number taken was not very great, and all were taken in the open sea, on the trawling grounds far from shore; none were taken in the shrimp-net or shrimp-trawls in the Humber.

These results agree with those of Dr. Fulton, published in the eighth Annual Report of the Scottish Fishery Board. I have for convenience fixed the limit between specimens one year old and two years old at 10 inches. It is evident from the entry for May 20th that a large number of year-old immature haddocks are brought to market by the trawlers.

Of *Gadus luscus,* the pout, only one specimen was obtained; it was $3\frac{5}{8}$ inches, 9·2 cm. long, and was taken in the sprat stake-net at Humberstone on January 29th. This specimen was probably hatched in the previous May or June, and was, therefore, about seven months old.

A number of young Motella, apparently *M. tricirrata,* were taken

in the surface tow-nets at various positions in the North Sea as follows:

July 8th.—About fifteen miles N. of Horn Reef Light-vessel, Jutland. One specimen $\frac{5}{16}$ of an inch (8 mm.).

9th.—Twenty and twenty-two miles N.N.E. of Horn Reef Light-vessel. Many specimens.

12th.—Inner shoal-water of Great Fisher Bank. Three specimens $\frac{3}{8}$ to $\frac{1}{2}$ an inch (9 to 13 mm.). Two specimens $1\frac{1}{8}$ to $1\frac{7}{16}$ inches (2·8 to 3·7 cm.).

17th.—West Shoal and West Spit of Dogger Bank. Many $\frac{3}{8}$ to $1\frac{5}{8}$ inches (·9 to 4·1 cm.).

23rd.—Two hundred and fifty miles E. of Spurn Light-vessel. One specimen $\frac{7}{16}$ of an inch (1·1 cm.). Many $\frac{9}{16}$ to $1\frac{3}{4}$ inches (1·4 to 4·4 cm.).

27th and 28th.—One hundred and fifty miles E. by N. of Spurn Light-vessel. Several.

August 10th.—West end of Dogger. Three specimens $\frac{7}{16}$ to $\frac{5}{8}$ of an inch (1·1 to 1·6 cm.). Many $\frac{7}{8}$ to $1\frac{13}{16}$ inches (2·2 to 4·2 cm.).

18th.—One hundred and fifty miles E. $\frac{1}{2}$ S. of Spurn Light-vessel. Five specimens $\frac{5}{8}$ to $1\frac{1}{16}$ inches (1·6 to 2·7 cm.).

These were evidently hatched in May and June and were therefore one or two months old.

The two families, Pleuronectidæ and Gadidæ, only are well represented in this collection, and the specimens of these have been considered in the preceding pages. The remaining few specimens belong to various families, and the greater number of them to species of no value in the market.

Clupea harengus (*Herring*).—Two specimens $6\frac{3}{4}$ and $7\frac{3}{8}$ inches (17·2, 19·7 cm.), taken in sprat stake-net, Humberstone sands, January 29th. These were probably a year and four or five months old, assuming that they were derived from spawn shed in autumn, in August or September.

Clupea sprattus (*Sprats*).—Three $3\frac{3}{4}$ inches (9·5 cm.), five $4\frac{1}{4}$ inches (10·8 cm.), one $5\frac{1}{4}$ inches (12·3 cm.), in the same net, same date.

These were all adult or nearly so; the smallest would probably be two years old, the larger three years in the following March or April.

Osmerus eperlanus (*Smelt*).

April 25th.—Five $3\frac{1}{2}$ to $3\frac{7}{8}$ inches (8·9 to 9·8 cm.), Cleethorpes, shove-net.

25th.—One $6\frac{5}{8}$ inches (16·9 cm.), Cleethorpes, shove-net.

July 3rd.—Three $4\frac{1}{2}$ to $4\frac{3}{4}$ inches (11·5 to 12·1), Cleethorpes, cart-trawl.

The smelt spawns about April, and the smaller specimens taken

at Cleethorpes were doubtless a year old, the specimen $6\frac{5}{8}$ inches long two years. The three taken in July were about fifteen months old.

Anguilla vulgaris (*Eel*).—A number of young eels, about $2\frac{1}{2}$ to $2\frac{3}{4}$ inches long (6·3 to 7·0 cm.), were taken on March 30th in the Humber, North Channel, at a depth of one to two fathoms by the shrimp trawl. Such young eels, very transparent at this size, are found everywhere in spring, and seem to be derived from spawn shed the previous autumn, so that they are three or four months old.

Scomber scomber (*the Mackerel*).—A few specimens were obtained by Mr. Holt in the tow-net.

July 9th.—Twenty-two miles N.N.E. of Horn Reef Light-vessel. Twelve specimens from 6·0 to 9·0 mm. (about $\frac{1}{4}$ of an inch).

27th and 28th.—One hundred and fifty miles E. by N. of Spurn Light-vessel. Three from 13·5 to 19·25 mm. ($\frac{1}{2}$ to $\frac{3}{4}$ of an inch).

These are the first young mackerel of the year's brood that have yet been obtained and recognised. The largest specimens already showed the specific characters, the smaller were larval. They will be described by Mr. Holt. The mackerel spawns in June and July, and the largest of these specimens were probably one to two months old.

Agonus cataphractus.

April 25th.—One $2\frac{1}{8}$ inches (5·4 cm.), Cleethorpes, shove-net.

28th.—Three $2\frac{1}{8}$ to $2\frac{5}{8}$ inches (5·4 to 6·6 cm.), Cleethorpes, shove-net.

May 10th.—Twenty $2\frac{1}{4}$ to 3 inches (5·7 to 7·6 cm.), two 5 to $5\frac{1}{2}$ inches (12·7 to 14 cm.), Cleethorpes, shove-net.

This species has adhesive ova, which at Plymouth are deposited in February and March, at Grimsby probably a little later. The specimens up to 3 inches I consider to be just over a year old, at 5 inches they may be two or three years, as the maximum length is only $6\frac{1}{2}$ inches.

Cottus bubalis.

May 10th.—Seven $2\frac{1}{2}$ to $2\frac{3}{4}$ inches (6·3 to 7·0 cm.), two 3 inches (7·6 cm.), one $4\frac{3}{4}$ inches (12·1 cm.), Cleethorpes, shove-net.

This species spawns early in the year, from January to March or April. The specimens up to 3 inches were probably in their second year, the last specimen, $4\frac{3}{4}$ inches, two years old at least.

Callionymus lyra (*the Dragonet*).—Twenty-nine specimens of this species, ranging from $1\frac{3}{4}$ to $2\frac{5}{9}$ inches in length, were taken in the shove-nets on April 25th and 28th. The adults spawn between February and May, and these small specimens were doubtless just a year old.

Gobius minutus.—This species lives on sandy shores, and is

always taken in shrimp-nets. At Cleethorpes, in the shove-net, April 25th, 261 were taken, ranging from $1\frac{1}{8}$ to $3\frac{7}{8}$ inches in length. These were of all ages, one year upwards, the adult not exceeding $3\frac{1}{2}$ inches. It spawns in spring.

Syngnathus acus (*Common Pipe-fish*).

April 25th.—Two $3\frac{1}{2}$ to $4\frac{3}{4}$ inches (8·9 to 12·2 cm.), at Cleethorpes, shove-net.

June 3rd.—Twenty-four $3\frac{1}{4}$ to $4\frac{7}{8}$ inches (8·3 to 12·4 cm.), at Cleethorpes, cart-trawl.

When adult this species is 12 to 16 inches long, so that these specimens are presumably not more than a year old ; but they are nearly all breeding, the males carrying ova, and many of the females full. These young specimens differ from the large adults in several characters, and appear at first sight to belong to a distant species. The subject is discussed in Günther's Brit. Mus. Catalogue, vol. viii, p. 159.

North Sea Investigations.

(*Continued.*)

By

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Naturalist on Staff in charge of Investigations.

I. On the Relation of Size to Sexual Maturity in Pleuronectids.

Introductory.—I believe that, so far as concerns the more important species, sufficient information has been accumulated to allow of the deduction of a reliable conclusion.

Though it is certain that some local variation exists in the different parts of the North Sea, I have not found it possible to treat the area otherwise than as a single district. This is of the less importance since the variation seems to be very slight, and in any practical application of the results arrived at I do not see how it would be feasible to subdivide the district.

It again becomes my pleasing duty to acknowledge much courtesy and assistance in carrying out my work. Without the permission of owners to examine the larger and more valuable kinds of fish without purchasing them, my records would be indeed meagre. I shall not attempt to enumerate those who have helped me in this way, as the list would comprise almost every smack-owner or fish merchant in Grimsby. The greater part of the work has been carried on, by kind permission of the Marine Fisheries Society of Grimsby, at the Cleethorpes Hatchery.

Scheme of Work.—The scheme upon which my deductions are based requires little explanation, since I have seen no good reason to change the opinion which I have expressed in a report upon the same subject for a different district (Sci. Proc. R. Dubl. S.,* vol. vii,

* Reprinted from the Report of the Council Royal Dubl. Soc. for 1891, Feb., 1892.

pt. 4, 1892, p. 418), that any biological definition of mature and immature fish must depend upon the conditions of the larger sex, or, strictly speaking, upon the sex in which, *as regards dimensions*, maturity is most retarded. This sex is almost invariably the female.

But it must be borne in mind that when a ripe or nearly ripe fish is caught there is, and I think can be, no means of determining whether it is spawning for the first time or has spawned in previous years. Consequently observations made during or shortly before the spawning season yield results that are only entirely reliable for the time of year during which they were made—for this reason, that a fish which by a narrow margin was either too young or too small, or from whatever cause was unfitted to spawn last season, will have very materially increased in length before the present season. In this connection researches on the rate of growth are of the highest importance, and without a greater knowledge on that subject than we already possess, it is impossible to form reliable conclusions. Much, however, may be done by continuing the examination of the reproductive organs throughout the year.

I do not know whether it will ever be practicable to utilise the evidence afforded by such fish in formulating any size limit for practical use. In any case the season is not sufficiently advanced for their consideration, and therefore in the tables which are appended I have only dealt with fish taken during, shortly before, or shortly after the spawning season. I believe that the size limits deduced from these will be quite as high as any that are likely to be acceptable, and that they will be sufficiently efficacious for the upkeep of the species.

The term "immature" is used in this paper to denote that the reproductive organs show no sign of activity, and to the best of my knowledge have not subserved a reproductive function in previous years.

Method of distinguishing the Different Conditions.—I have studied the conditions of the female reproductive organ with much more attention than has been devoted to that of the male, since the larger size and numerical preponderance render the former sex infinitely the more important in the present connection. In the case of the male I have relied chiefly on the external characters of the testis, viz. those of size, contour, and apparent consistency, since these seem to be sufficient for the purpose, except in the case of the sole, which has required more careful attention than the rest.

In the immature female, the ovary, so soon as it is large enough to be easily perceptible, is found to contain a number of minute translucent ova, their size and condition depending neither upon the season of the year nor upon the size of the fish. Thus there is no

obvious difference in the ova of two plaice of five and ten inches respectively.

The first approach to maturity is denoted by an enlargement of some of the ova, and by various changes in their internal structure (well known to students of Teleostean embryology), of which we need notice only one. This is the assumption of an *opaque* condition ;* and since it is the character which is most readily apparent, I have utilised it in separating ova which are approaching an individual participation in the reproduction of the species from such as either will or may be absorbed without ever ripening. The former, for the purposes of the present work, may be termed "active," and the latter "inactive" ova, without implying the actual difference denoted by the two words. Even before they are actually visible to the naked eye, the presence of "active" ova may be detected in a germinal epithelium by a change in the coloration and consistency of the latter.†

Mr. Cunningham, in the last number of this journal, p. 227, deplores the absence of any criterion by which one can find out whether a fish has spawned or not ; if the fish be not ripe or ripening when caught "it may be sexually immature, or it may have spawned previously, its sexual organs being merely in an inactive state at that particular time of the year."

To establish such a criterion has, of course, been an essential part of the present research ; as a result, I am satisfied that the features upon which I myself, and I suppose most other observers, have been accustomed to base a diagnosis, are adequate for the purpose, provided a careful examination is possible.

I have met with no single character, nor even combination of several characters, which has a general applicability in this matter for Teleosteans as a whole. The variation in structure and disposition of the reproductive organ is so remarkable that a different treatment may be required even within the limits of a single genus.

As we are here dealing only with the flat-fishes, there is no need to advert to other forms, and I shall therefore confine myself to discussing the conditions in so far as they affect the former alone.

Undoubtedly the most important point is the distinction between immature and spent (and resting) fish.

The most important characters in distinguishing these stages may be enumerated, in the order in which they become apparent, as follows:

* The changes which give rise to the opaque condition are not the same in all species, but they occur at much the same stage of development, and appear to possess the same significance.

† Specimens in which the ovaries exhibit the other characters of immaturity, but in which the largest ova are just passing from the "inactive" to the "active" condition, are included in the tables amongst the immature.

(i) Size and appearance of ovary.
(ii) Topographical relationships of ovary.
(iii) Size and condition of living ova.
(iv) Presence of ripe ova which have failed to be extruded at the time of spawning.

Characters (i) and (ii) are essentially dependent on each other, and their interpretation varies with the species in a manner which I shall attempt to indicate below.

In the next character (iii) we have, I suppose, the clue to the difficulty in distinguishing immature and spent fish, since one may find, in the ovaries of a fish which from its large size might be supposed to have spawned at some previous time, only such "inactive" ova as I have described above. I have, however, never met with such a condition, during the spawning season, in any fish which might not, from its contiguity in size to a series of obviously immature examples, be reasonably supposed to illustrate the variation in the assumption of the mature state.

It is still too early in the season to ascertain whether a period of inactivity is a regular feature in the rhythm of ovarian development in all Pleuronectids, since some are still spawning, and others have only recently ceased to do so.

I have met with no such condition in the plaice, which is the earliest spawner of all (with the doubtful exception of the halibut, about which little is known), though I have made somewhat careful inquiries into the ovarian condition of that species since the end of the spawning season. Dabs, however, which presumably spawned about April, now* exhibit a germinal epithelium entirely destitute of active ova.

It need hardly be said that the last character (iv) is an infallible proof of previous spawning when it is present.

In all species which I have studied a certain number of ripe ova fail to make their escape, and remain to decompose either in the lumen of the ovary itself or in the ovary duct. But their number, and the period during which their presence can be ascertained, appear to vary with the individual and also with the species. Thus I believe that they are most numerous and perceptible for the longest period in the plaice, perhaps because this species has the largest ova; and I have no doubt the lemon sole is the form in which this character gives us the least assistance. I have received a plaice with ovaries enormously distended with ripe, yet dead and slightly decomposed ova, and though outside pressure caused these to be extruded, it was evident that their deposition was beyond the power of the parent.

* In September.

That the ova of an individual female are not shed all at once, but in successive crops, is well known (cf. Fulton, *Comparative Fecundity of Sea Fishes*, Rep. S. F. B., 1891, p. 245), and I think that the different degrees in which the retention of ripe ova obtains in different species must be explained by the difference in the size of and interval between the several crops. In the plaice, and in some other species, a greater number of ova, compared to the capacity of the ovary, ripen together, and the successive crops appear to overlap each other to some extent, so that there never seems to be a time when some ova are not ready for extrusion. Consequently the muscular efforts for extrusion have the co-operation of the constant and rapid increase of the successional crops, so long as any such remain; but when it comes to the turn of the last crop the elasticity of the walls of the ovary and the muscular power of the parent are so insufficient that a comparatively large number fail to make their escape.

In the lemon sole, on the contrary, I have evidence that the crops are individually small (compared to the capacity of the ovary), and separated from each other by intervals which, though imperceptible in the spawning period of the species, must be well marked in individual parents. The fish must therefore possess resources, muscular or otherwise, which render it practically independent of the assistance afforded by the successional crops in extruding the ripe ova (the difficulty being lessened by the comparatively small number of the latter which are simultaneously ready), and thus does not encounter any unusual obstacle in disposing of the last crop.

Before dealing with the topographical features of the ovary in its different conditions we must briefly advert to the modifications exhibited in the disposition of the viscera in the various species.

As is well known, the ripe ovaries in any flat-fish are disposed on either side of the hæmal spines, and extend from a point in the neighbourhood of the bony buttress which forms the centre of the hind wall of the peritoneal cavity to a greater or less distance from the commencement of the caudal peduncle. A single ovary duct, formed by the coalescence of the duct from either ovary, follows the course of the buttress in its anterior curve to the genital orifice.

But while all have this much in common in the ripe condition, the British representatives of the family fall into two groups, based upon the arrangement of the alimentary canal and the shape of the reproductive organ:

(*a*) including the halibut, long rough dab, turbot, brill, megrim (scald-fish and topknots ?), plaice, flounder, and common dab.

In these no portion of the alimentary canal extends to any considerable distance beyond the first hæmal spine. The ovaries are

subequal in size, and markedly dilated dorso-ventrally in their anterior region. The kidney is situated in the roof of the peritoneal cavity, in front of the great hæmal spine, and the urocyst between the anterior ends of the ovaries and their ducts.

(*b*) including the lemon sole, the witch or pole dab, the common sole (and probably other members of the genus *Solea*).

In these a loop of the ileum passes back on the *ocular** side of the hæmal spines for a greater or less distance (greatest in the sole, least in the witch). The ocular is consequently much smaller, having less space at its disposal, than the blind ovary, and neither is very markedly dorso-ventrally dilated in its anterior region. The excretory organs are as in group (*a*) in the lemon sole and witch, but in the true sole the urocyst and the hinder part of the kidney pass back on the blind side of the anterior hæmal spines.

In immature fish of group (*a*) on removing the body-walls of the abdominal region on either side the free anterior portions of the ovary are seen to form, with the bony buttress, the hind wall of such part of the body-cavity as lodges the alimentary viscera. The one ovary is a little in front, the other a little behind the buttress, or both may be to some extent united in front of it. They appear as plump cushion-like structures, following the course of the buttress, rounded off near its origin, and tapering into the ovary ducts towards its distal extreme. Passing the finger backwards along the external surface of the fish no groove is perceptible, in fresh specimens, between the region of the vertebral column and that of the interhæmal bones. Dissecting away the anterior muscles of the caudal region, we find that each ovary is continued backwards for a short distance alongside of the hæmal spines in a tapering process terminating in a moderately fine point.

The length of the posterior process, as compared with the distance between the first hæmal spine and the caudal peduncle, varies with the species and with the size of the individual, but probably in no case exceeds one third, and is usually much less. The whole structure is very plump and firm, and is firmly embedded between the hæmal arches and the caudal muscles. If a seeker is pushed backwards in the direction of the posterior process a considerable amount of closely set connective tissue will be ruptured in its progress.

On cutting into the ovary its lumen is found to be entirely or nearly occluded by germinal epithelium, beset with inactive ova of various degrees of minuteness.

* The terms "ocular" and "blind" are used in this paper, since they are intelligible in connection with Pleuronectids, and, while eliminating the confusion between right and left in dealing with a mixture of dextral and sinistral forms, do not, as it were, outrage morphology like Fulton's qualified use of "dorsal" and "ventral."

Now if we examine a spent female of the same group the conditions are very different. In the first place, the anterior or free region of the ovary is enlarged and flaccid ; a distinct depression can be felt from the outside on either side of the hæmal spines, extending well-nigh to the caudal peduncle. On removing the muscular wall in this region we find the posterior process of the ovary much elongated, thin, and flaccid, and very loosely lodged between the spines and the muscles ; whilst in the anterior region the connective tissue which formerly united the muscular and skeletal elements ventral to the front of the ovary may have to a great extent disappeared, so that a mesentery forms in this region the only boundary between what one may term the alimentary and reproductive portions of the visceral cavity. The length of the ovary is variable, but is seldom if ever less than half of that between the first hæmal spine and the caudal peduncle.

On opening the ovary the contents are found to vary according to the time which has elapsed since spawning. If the latter is recently over, the germinal epithelium shows traces of ruptured follicles, and more or fewer ripe and decomposing ova are to be met with ; at this stage their nature will be at once obvious. In spent fish at any period which I know the lumen of the ovary is wide, and the germinal epithelium of the posterior process is arranged in conspicuous longitudinal ridges. It may contain, as in all plaice which I have examined, a number of small "active" ova, in addition to a host of "inactive" ones, but I am uncertain whether these represent the early condition of next season's crop, or only ova which, though they pass the inactive stage, are absorbed without ever reaching a considerable size. It appears most probable that after spawning the ovary continues for some time to produce a certain number of active ova, which, however, are successively absorbed, without ripening, until the approach of the next season. Otherwise it is necessary to suppose that an ovum in this species, and others which in this respect agree with it, takes the best part of a year to ripen after it has passed the "inactive" condition.

The dab is so far the only form in which I have found only inactive ova in the germinal epithelium of spent ovaries.

Of a number of females examined in August the ovaries of most exhibited the features which I have just described as characteristic of spent fish, but in three the characteristics were those of immature fish. There was no difference whatever in the ova in the germinal epithelium, but on instituting a careful search certain whitish gelatinous bodies were met with in the ovary ducts of some of the larger fish. These proved to be the remnants of ripe ova, the zona being the most recognisable feature. There could be no doubt that

the fish which contained such bodies had spawned, and it was reasonable to suppose that those which showed no traces of retained ova had either spawned a little earlier or had lost these substances a little sooner than the rest. The chief question is whether the fish which agreed with my ideas of immaturity might not really represent a further stage in a period of inactivity after spawning. We know that when the ovary ripens for the first time its posterior process forces its way backwards between the caudal muscles and hæmal spines towards the tail, thus attaining the elongation which is familiar in the ripe condition. When the ova have been discharged the elasticity of the ovary walls causes a considerable shrinkage, apparently at once; so that a recently spent ovary is always shorter than one full of ripe ova, as well as much narrower. It may be suggested that this process of shrinking is continued until the ovary has reached the proportions and shape of an immature example, the muscles and connective tissue also closing in on it. If this were so, there could be no possible way of distinguishing the spent from the immature condition apart from the presence of the remains of ripe ova of a former crop.

My evidence, however, points to the opposite conclusion, viz. that the ovary, once spent, never reverts to a condition resembling that of an immature fish. The fish I have referred to were nine in number, and consisted of seven, diagnosed as spent, from $10\frac{3}{4}$ to $14\frac{1}{2}$ inches; the three apparently immature forms measuring 11, $11\frac{3}{4}$, and 12 inches respectively. Now, speaking as a general rule, it is the largest fish of a species which spawn the earliest; and since the ovary after spawning must needs pass through the wide-walled flaccid condition, with traces of retained ova, before it could reach the hypothetical stage in which it might ape the immature condition, one would expect to find the latter in the largest instead of, as is here the case, in nearly the smallest specimens. Eleven or twelve inches is a far larger size than that at which many dabs spawn for the first time; but this is of little importance, since some are quite immature up to 9 inches during the spawning season, and, from the rapidity of growth which Cunningham has demonstrated in the species, we can understand that a fish which fails to reach the required standard, whatever it be, at the time of year favorable to the maturation of the reproductive organs, will materially increase in length before the opportunity again presents itself.* Apart from this I do not see how it is possible for the ovary to shrink to such an extent. It would involve the atrophy of the greater part of the ovarian substance, and there is no evidence

* Probably the growth will be more rapid than in a mature fish, since there will not be the same drain on the resources of nutrition for the development of the sexual products.

of such a process. I have certainly met with an instance of atrophy of the ovaries in another species, but it was evidently of a pathological nature, and conducted along lines which seemed very unlikely to result in a simulation of the immature condition (*vide* p. 382).

To recapitulate, I would state that when retained ova are not present to place the matter at once beyond doubt, a spent can always be distinguished from an immature ovary by the wide flaccid anterior region, by the greater length of the posterior process,* and by the loose manner in which the latter is lodged in the cavity alongside of the hæmal spines. Indeed, if the specimen is fresh, a groove, which can be felt by passing the finger along the skin in this region, is almost a sufficient test; but if the fish is more or less stale, the groove is to some extent perceptible even in immature fish.

The members of group (*b*), viz. the common sole, lemon sole, and witch or pole dab, present rather more difficulty, as there is never any great dilatation of the anterior part of the ovary, and its posterior process is more or less elongated from a rather early period. In soles of three or four inches, and in lemon soles of six inches (the smallest I have been able to procure), it is already considerably developed. Moreover in all forms the backward extension of the gut on the ocular side prevents any constriction of the corresponding ovary by the caudal muscles; and in the case of the sole the same effect is attained on the blind side by the disposition of the hind part of the kidney and the urocyst. In the lemon sole and pole dab the ovary is the only occupant of the cavity on the blind side of the hæmal spines; yet in the former it is but little occluded by connective tissue in the posterior region at any period, whilst even the anterior part, which is so firmly fixed by the caudal muscles in immature members of group (*a*), is always comparatively loose. I have not been able to examine enough small pole dabs to know whether the same holds good for that species also, but I believe it is the case.

A recently spent ovary can, of course, be easily detected as such by the nature of the germinal epithelium, and usually by the presence of retained ripe ova. Thus in the sole the degenerating follicles, deeply coloured by hæmoglobin, are very conspicuous, much more so than in any other species I have studied. Again, ova which have passed the inactive condition have been present in all spent ovaries which I have examined, and entirely absent from specimens I have considered to be immature. The ovary itself is also longer and wider, and flaccid anteriorly in the former condition, and narrow, plump, and rounded in the latter, but more conspicuously so in the sole than in the lemon sole. The length is a matter of comparison; thus in the sole I have not found immature ovaries to exceed two

* This is, of course, a matter of comparison, according to the species.

fifths of the distance from the first hæmal spine to the caudal peduncle, whilst spent ovaries have always been longer. It is as yet too early to summarise the proportional differences in the lemon sole, as the spawning period is apparently very protracted in individuals as well as in the species; but it seems that a spent ovary is always wider and longer than an immature one. Nor is it yet possible to ascertain to what extent the shrinkage of a spent ovary is carried, either in the sole or in the lemon sole, or whether, by the absorption of the small active ova, an entirely inactive germinal epithelium is ever met with in spent examples. Should this occur, and no retained ova be present, it would be extremely hard to distinguish the condition in a lemon sole. An instance, which I suppose to be exceptional, of the degeneration of a spent ovary has come under my notice in the sole. The wall of the posterior portion of either ovary had become disintegrated, and fragments of the germinal epithelium had consequently found their way into the general cavity which lodges the ovary, whilst on the blind side similar matter, containing both active and inactive ova, had penetrated between the muscles of the interhæmal ridge and between the bases of several of the anal fin-rays and the skin. I suppose that this process of atrophy would in time have extended to the rest of the ovary, but clearly it would not result in any condition resembling that of an immature example.

It need hardly be said that when an ovary agrees with the immature condition in other respects, but exhibits an activity in the germinal epithelium, it is reasonable to suppose that the fish is about to spawn for the first time. Thus the distinction between an ovary ripening for the first time and for any subsequent time is not hard, so long as it is only in the early stage of maturation. The difficulty is felt when the organ has attained a considerable development, such as would, in the case of a fish that had already spawned, suffice to obliterate the traces by which such condition might otherwise have been recognised.

It has been difficult, notably in the case of the turbot and brill, to obtain sufficient numbers of females at the critical sizes, since amongst the smallest members of any species brought to market the males are always infinitely more numerous than the females; the converse, of course, holding good amongst the larger examples, which are of less interest for the purpose in hand. The accompanying figures must not be taken as indicating the relative abundance of the sexes at the different sizes, since, in selecting fish for examination, I have often had to reject large numbers of males, from want of time for the record of their condition.

I may here remark that, according to my experience, whenever a catch of fish from an offshore ground, especially in the spawning

season, includes both large and rather small fish—say from the full size down to the smallest size of mature males,—the limit of size which divides mature from immature females will be found to practically separate the two sexes. Thus most of the larger fish will be mature females, and most of the smaller ones will be mature males, with a sprinkling of immature members of both sexes. This is in complete accord with Fulton's observations on the distribution of fish on the spawning grounds (Rep. S. F. B., 1890, 178), and it is noteworthy as an impediment in the way of the rigid application of a size limit based on the condition of the larger sex. But it is not of the highest importance, since the number of small fish in such cases is, by comparison, insignificant (thus following the well-known proportionate abundance of the sex), and it is only applicable to such species as show a marked change of habitat in apparent relation to the spawning instinct, and is variable within the limits of a species according to locality.*

Local Variation.—A comparison of the results obtained by work on the different coasts of Great Britain suggests a speculation on the rate of growth in relation to maturity.

Thus I understand from Messrs. Calderwood and Cunningham that at Plymouth the plaice spawns at about 10 inches, a marked contrast to the North Sea or even the west of Ireland conditions. Again, Cunningham has found mature lemon soles (*supra*, No. 3, p. 244) about as small as any which I met with on the west of Ireland. With regard to the common sole, the limit proposed for this district and for the west of Ireland is held by Mr. Calderwood to be equally applicable to the Plymouth district, whilst Mr. Cunningham would put it only a trifle lower.

Now soles appear to be much the same size on all three coasts, lemon soles are much larger in the North Sea than in the other districts, and according to Cunningham (*supra*, No. 2, p. 100) plaice are much smaller at Plymouth than in the North Sea. West of Ireland plaice appear to be intermediate in size, but in this respect approach the North Sea rather than the Plymouth fish, though, as I had not much material on which to base my Irish limit for this species, this is not of much importance.

We see, therefore, that where there is agreement in the size of fish of a species in any two or more districts, there appears also to be agreement in the size at which sexual maturity is reached, and that when there is variation maturity is reached at the smallest size in the district where the species is smallest.

* *E. g.* it appears to apply to turbot on the Dogger, whilst on the eastern grounds spawning and immature turbot may be caught together, the latter far exceeding the former in number.

We are aware, from Cunningham's researches on the rate of growth, that this varies with the size in different species; and from the remarks of the same author on the plaice (*supra*, No. 2, pp. 99, 100) it appears that the same principle is applicable to local variation of size within the limits of one species. Hence it would appear that local variation in the size at which sexual maturity is reached is explicable by, or implies, variation in the rate of growth, and involves no local difference in the age* at which fish spawn for the first time.

Size Limits for the North Sea District.—The following measurements are intended to represent the average sizes at which the female spawns for the first time in the North Sea district, so far as such are ascertainable from observations made during, shortly before, or soon after the spawning season:

Turbot	18 inches.	
Brill	15 ,,	
Common sole	12 ,,	
Plaice	17 ,,	
Lemon sole	12 ,,	
Halibut	36 ,,	(provisional).
Common dab	7 ,,	

I have not paid much attention to the common dab (*Pleuronectes limanda*); the smallest ripe female I have seen measured 6 inches, and the largest immature female, during the spawning season, 9 inches. Flounders (*P. flesus*) and long rough dabs (*Hippoglossoides limandoides*) have not been available in sufficient numbers for a satisfactory conclusion. The same applies to the megrim (*Rhombus megastoma*), which is rather a rare fish on the grounds usually worked by Grimsby trawlers, and the witch (*P. cynoglossus*); but it is worthy of note that twelve female witches of 12 and 13 inches and two of 14 inches were immature, whilst one of 14 inches was three parts ripe. Hence it seems likely that the fish does not spawn at so small a size (12 inches) as on the west coast of Ireland. I have never seen a sand or lemon sole (*Solea lascaris*), and only one solanette (*S. minuta*) and scald-fish (*Arnoglossus laterna*) in the Grimsby district. None of the remaining British Pleuronectids, the topknots, have been met with.

The following tables are abstracted from my records, and comprise only the fish at the critical sizes examined between the dates specified. It will be understood that all larger fish examined were found to be mature, the converse holding good in the case of smaller fish.

* Allowing for the individual variation in one locality which Cunningham has shown to exist in this feature (*supra*, No. 3, pp. 224, 225).

Turbot (*Rhombus maximus*).

April 1st to September 12th, chiefly during the spawing period.

Length.	MALE.				FEMALE.			
	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.
At 11 inches	3	0	3	0	0	0	0	0
12 „	14	2	11	1	2	0	0	2
13 „	39	13	24	2	15	0	0	15
14 „	39	16	22	1	45	0	2*	43
15 „	25	13	12	0	41	0	6*	35
16 „	42	23	19	0	14	0	1*	13
17 „	73	50	23	0	25	0	13	12
18 „	78	54	23	0	28	2†	12‡	14
19 „	60	46	14	0	36	8	27	1
20 „	33	22	11	0	68	22	45	1§

The *male* seems to come to maturity at about 12 to 15 inches. Though I believe that some few females may spawn at 17 inches, I have no positive evidence to that effect, and I am convinced that 18 inches is the lowest size that could be usefully employed in defining a limit between mature and immature.

Spawning period.—A very few fish seem to spawn as early as the end of March, and a few during April. Spawning becomes more general towards the end of May. The chief period is June and July. The number of ripe females diminishes throughout August, but a few do not finish spawning until early in September.

Brill (*Rhombus lævis*).

April 1st to June 30th.

Length.	MALE.				FEMALE.			
	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.
At 10 inches	1	0	0	1	0			
11 „	1	0	0	1	0			
12 „	9	2	2	5	0			
13 „	40	24	8	8	7	0	6	1
14 „	54	44	9	1	25	0	20	5
15 „	29	22	7	0	26	8	18	0
16 „	19	16	3	0	20	2	18	0
17 „	11	9	2	0	8	2	6	0
18 „	7	7	0	0	4	2	1	1

* Reproductive organs very little advanced.

† Exact size, 18½ inches.

‡ One three parts ripe, the rest half ripe.

§ Examined after the spawning period.

It appears that the *male* is mature at from 12 to 15 inches, as in the turbot, but probably some smaller specimens, if procurable, would be found mature.

The margin of variation in the size at which the *female* first spawns appears to be rather more narrow than in most other species ; but it was impossible to obtain small females in sufficient numbers.

Spawning period.—Spawning appears to commence in the latter part of April, and becomes general by the beginning of May. It is continued throughout that month and the early part of June, after which it diminishes, and is practically over by the end of July. The spawning period is thus much the same as that of the common sole.

Plaice (*Pleuronectes platessa*).

From February to June, the larger fish chiefly during the spawning season.

Length.	MALE.			FEMALE.		
	No. examined.	Mature.*	Immature.	No. examined.	Mature.*	Immature.
At 6 inches	1	1	0	3	0	3
7 ,,	5	0	5	7	0	7
8 ,,	37	0	37	43	0	43
9 ,,	98	3†	95	114	0	114
10 ,,	71	1†	70	73	0	73
11 ,,	33	0	33	36	0	36
12 ,,	15	0	15	27	0	27
13 ,,	12	3	9	23	1	22
14 ,,	14	7	7	19	0	19
15 ,,	5	3	2	21	6	15
16 ,,	7	7	0	10	4	6
17 ,,	7	7	0	12	9	3
18 ,,	3	3	0	5 + ∾	5 + ∾	0

The occurrence of a ripe *male* at 6 inches is probably altogether exceptional, 15 inches appearing to be nearer the usual size at which the male becomes mature, but I did not pay very much attention to this sex during the spawning season.

At 17 inches the proportion of mature *females* is much greater than shown above, as in selecting fish of this size for examination I have picked out those which seemed likely to prove immature Conversely, at sizes less than 17 inches, those which appeared to be mature were selected.

At 18 inches I have seen in the market numbers of evidently

* Nearly ripe, ripe, or spent, except † in which the reproductive organs very little advanced.

mature fish, and am convinced that percentage of immature at that size during the spawning season is infinitesimal.

A female of 19 inches was found to be immature, but this was some months after the spawning season.

Spawning period.—From the middle of January to the end of March, but some seem to spawn in April, and a few perhaps as late as May. It seems probable that spawning also takes place to some extent earlier in the winter, but of this I have not yet sufficient vidence.

Common sole (*Solea vulgaris*).

From February to September 12th, chiefly during the spawning season.

Length.	MALE.				FEMALE.			
	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.	No. examined.	Ripe or nearly spent.	Approaching ripeness.	Immature.
At 6 inches	0				2	0	0	2
7 ,,	4	0	0	4	3	0	0	3
8 ,,	29	1	3	25	45	0	0	45
9 ,,	28	4	13	11	66	0	0	66
10 ,,	38	15	22	1	28	1*	8	19
11 ,,	33	6	24	3	26	0	14	12
12 ,,	9	2	7	0	33	3	26	4
13 ,,	7	3	4	0	18	2	16	0
14 ,,	3	2	1	0	10	4	6	0

Ten inches appears to be the usual size at which the *male* reaches maturity.

Though, as appears above, a *female* may occasionally spawn at $10\frac{1}{2}$ inches, I am convinced that comparatively few spawn at less than 12 inches, and I have no evidence of immature fish at more than 12 inches during the period of observation.

Spawning period.—Ripe females begin to appear at the end of April, and are abundant during May and June, which seems the chief spawning time. They become scarcer during July, and spawning is practically over by the early part of August.

Spent females begin to appear in the Humber at the beginning of July, and become more numerous as the month goes on, and continue to abound during August and the early part of September.

* Exact length, $10\frac{1}{2}$ inches.

Lemon sole (*Pleuronectes microcephalus*).

February to September, chiefly during the spawning season.

Length.	MALE.				FEMALE.			
	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.	No. examined.	Ripe.	Approaching ripeness.	Immature.
At 6 inches	1	1	0	0	2	0	0	2
7 "	20	10	4	6	22	0	0	22
8 "	12	10	1	1	22	0	1	21
9 "	39	29	10	0	34	0	9	25
10 "	60	56	4	0	51	3	24	24
11 "	41	31	9	0	47	1	22	24
12 "	23	20	3	0	14	1	12	1
13 "	11	9	2	0	10	2	8	0
14 "	5	5	0	0	10	7*	3	0

It appears that the *male* may be mature at 6 inches. No smaller specimens of either sex could be procured.

I do not think that many *females* spawn at less than 12 inches, though, as appears above, some spawn when only 10 inches in length.

Spawning period.—Ripe females first appear in the latter part of April; they are abundant in May, more so in June and July. No spent females were met with until the latter part of August, although search was constantly made for them. Many fish are still spawning in the early part of September.

The protraction of the spawning period is evidently due to the fact alluded to elsewhere (p. 368), that the ova of a single individual are produced in successive crops in one season, separated from each other by an unusually great interval of time.

Halibut (*Hippoglossus vulgaris*).

More of my material was derived from Iceland and Faroë than from the North Sea. I know very little about the spawning period. Parnell gives the spring for the coast of Scotland. Grimsby liners seem to know very little of it, and are divided in opinion; one of my informants thought he had seen spawning fish in April, but the general opinion seems to be that spawning does not take place until autumn or early winter. Probably, since the halibut is mainly a line fish, very few ripe females come under the notice of fishermen. Ripe males seem to occur more or less at all seasons of the year.

The only fully ripe female which I have seen occurred at the end of April. Another female, with enlarged ovaries, was found to

* One of these recently spent.

contain a few ripe ova at the end of August. The condition of other large females at about the same time and in the early part of September seems to indicate that some spawning will take place in the autumn, on the Iceland grounds, at any rate. Very likely, as in the case of the haddock, the North Sea fish spawn earlier, but of this I have no evidence.

The fish enumerated below were examined at various dates between February and September (inclusive), and do not take into account a number of large fish which I have looked into from time to time, in the hopes of finding ripe ova.

Owing to the large size and high price of halibut, their purchase in any considerable number was out of the question. I have, therefore, had to depend, for the most part, on eye observations made in the market, checked so far as possible by the careful examination of a limited number in the Laboratory. In the case of females, the method of observation is indicated in the accompanying figures.

Total number of fish examined, 150; males, 64; females, 86.

Males.—*Immature.*—1 at 15 inches, 2 at 16, 1 at 19, 1 at 20, 2 at 21, 2 at 22, 1 at 28, and 1 at 29.

Approaching ripeness.—1 at 24, 1 at 25, 1 at 27, 1 at 28, 6 at 30, 4 at 31, 4 at 32, 2 at 33, 4 at 34, 3 at 35, 1 at 36, 3 at 37, 1 at 38, and 9 from 34 to 37.

Ripe.—1 at 31, 1 at 37, 1 at 38, 1 at 41, and 2 over 50.

Spent.—1 at 30, 1 at 31, 1 at 33, 2 at 34, and 1 at 35.

It appears, therefore, that the male may be mature at about 30 inches, and is probably never mature at less that 25 inches.

Females.—*Immature.*—2 at 14 inches, 1 at 16, 2 at 24, 2 at 30, 1 at 31, 2 at 32, 1 at 33, and 1 at 35. Examined in the Laboratory.

Immature, or very little advanced towards maturity.—4 at 28, 1 at 29, 3 at 30, 2 at 32, 5 at 33, 4 at 34, 4 at 35, 3 at 36, 2 at 37, 3 at 38, 1 at 39, 1 at 40, 2 at 41, 2 at 42, 1 at 44, 1 at 47, 1 at 49, 11 from 37 to 47. Examined in the market.

Approaching ripeness, ovaries distinctly enlarged.—1 at 43, 1 at 45, 1 at 49, 1 at 50, 1 at 56, 1 at 59, and 15 over 60. Examined in the market.

Ripe.—1 at 73 inches.

The inference is that, if the observations made in the market are approximately correct, the female does not spawn until she is about 4 feet long; but I would prefer to await the results of continued work in the later months of the year, and to make use, *pro tem.*, of a limit of only 36 inches.

II. On the Destruction of Immature Fish in the North Sea.

Introductory.—The subject has unfortunately become so familiar in recent years that it is unnecessary for me to refer, except very briefly, to its previous literature. The most important contributions have been those by Professor McIntosh, in the Report of the Trawling Commission, 1884, by Dr. Wemyss Fulton in the Annual Reports of the Scotch Fishery Board, 1890 and 1891, and by Messrs. Bourne and Cunningham in previous numbers of this Journal. I have contributed what information I could collect during the Royal Dublin Society's survey on the west coast of Ireland in the Scientific Proceedings of that Society, 1892, pt. 4, and at the recent meeting of the British Association the subject was dealt with in a joint paper by Mr. Calderwood, Mr. Cunningham, and myself.

In the present paper I have attempted to put in as brief a form as possible the information collected during the Association's investigations in this district, together with suggestions as to what appear to me to be the best methods of remedying the evil.

The methods of fishing in use by boats from Grimsby and its neighbourhood are as follows:

i. Beam-trawling, by steam and sailing smacks, from 60 to 100 tons each.

ii. Long-lining by similar vessels.

iii. Shrimp-trawling by small sailing vessels in and about the Humber estuary.

Other vessels are employed in the deep-sea oyster fishery, and a certain number of small boats are engaged in whelking.

The following shore fisheries are carried on along the southern shore of the Humber below Grimsby:

i. Stake-netting.

ii. Ground-seining.

iii. Shove-net shrimping.

iv. "Seine" shrimping.

I propose to glance very briefly at each of the above industries in so far as they are concerned in the destruction of immature fish.

Beam-trawling.—The conclusion arrived at by Mr. Bourne, as a result of observations made in the Plymouth district, was that no material damage was done by the above industry (*supra*, vol. i, No. III). Such is certainly not the case in the North Sea district.

From my own experience on board of trawling vessels on most of the North Sea grounds, and from the recorded observations of a number of trawling skippers, who have been kind enough

to assist me in this matter, I find that a certain proportion of immature fish of valuable species are taken in almost every haul, whilst on certain grounds lying to the eastern side of the North Sea the catch consists almost entirely of immature plaice. This fact is only too well known to every one connected with the industry in this district, and has given rise to the periodical fishery conferences with which we are familiar.

At the same time I am not aware that any statement of the actual quantity of small fish which is destroyed on these grounds has ever been put forward, nor am I in a position to do so, since it is impossible to estimate the amount that is shovelled overboard, dead or dying, as failing to reach even the very modest standard of market requirements. I can, however, give the number of boxes which have been landed at Grimsby during the present season, containing only small fish. I am using the word "small" not in the biological sense, so as to include all sexually immature fish, but in the sense in which it is used by fishermen and others connected with the trade, so that it may be taken that the fish here enumerated are immature in every sense of the word. Very few of them are as much as 15 inches long, whilst in most boxes none exceed and few reach a length of 14 inches, the majority being from 7 to 13 inches in length. Boxes which, while containing a few fair-sized fish at the top, consisted otherwise of under-sized fish, are not included in the list.

There were landed at Grimsby—

In April,	1836	boxes of	small plaice.
„ May,	830	„	„
„ June,	3470	„	„
„ July,	2059	„	„
„ August,	1924	„	„

Total number of boxes for the five months, 10,119.

It is probable that the number is actually greater, as some boxes may well have escaped my notice; at any rate, the number is not exaggerated.

Such boxes as I have counted contained about 300 fish, but probably some contain less when the larger fish are picked out and packed separately. We shall be well on the safe side in taking 250 as the average number, which gives us a total of 2,529,750, or, in round numbers, two and a half million fish.

It must be remembered that these figures represent only the fish landed at Grimsby. During the present year only a single small fleet, about twelve sail, has been working the small fish grounds from Grimsby, most of the smack-owners having given orders to their boats to keep away from them. So far as I know, only one steam

trawler has visited them with any regularity, though a good many others have been making occasional trips there. The balance of boats bringing in small plaice has been made up by a certain number of smacks "single-boating," and sticking with more or less regularity to the eastern grounds. Now from Hull alone two fleets, each exceeding 200 sail, have this year visited the small-fish grounds, as has also the combined Yarmouth, Lowestoft, and Barking fleet, but as to how long they remained there I have at present no information. Steam trawlers have also been "across" from Hull and Boston. As the Board of Trade statistics do not discriminate between large and small fish of a species, I do not know how we can arrive at an accurate knowledge of the total number of small fish landed at all ports; but I think that there is sufficient evidence, from the results achieved by the small number of Grimsby vessels, that it must have been enormous. The small fleet alluded to is still on the same ground.

Space does not permit me to enumerate the different grounds frequented by these small plaice in any detail. Briefly, they extend along the coast of Holland, Hanover, and Denmark, as far north as the Horn Reef, and from thence to Hantsholm on the coast of Jutland. They derive their names in most part from those of the islands nearest to them, strangely transformed in some instances by British pronunciation. They differ considerably in the quality of the fish produced, some grounds yielding none which are too small for market, others yielding more unmarketable than marketable fish, whilst north of the reef some grounds which seem to produce only small fish in the summer yield fine catches in the autumn.

There is no doubt that nearly all the plaice which are too small for market are, nevertheless, destroyed, not wantonly, perhaps, but simply because the exigencies of the fisherman's business do not permit of much attention being paid to any but marketable fish, even if the rest are not fatally injured by the pressure exerted by the large catches usual on these grounds before ever they reach the deck.

Plaice are not the only sufferers on these grounds, as large numbers of immature turbot are also destroyed. So far as I can gather from observations on the total number in the market on various days previous to the opening of the season for the grounds referred to, the proportion of immature turbot does not exceed 30 per cent., but once the boats begin to go "across" it rapidly rises. This is easily accounted for when we examine the catches from the eastern grounds.

Thus in May a steam trawler from the Borkum ground landed 216 turbot in two trips. Of these only six were above 17

inches,* whilst in one of the trips, when 105 fish were caught, no less than 68 were under 13 inches.

During June the aggregate of thirty-one trips of steam and sailing vessels from the Dutch, German, and Danish coasts was 4623 turbot, of which 786 were mature and 3837 immature. The proportion of immature is thus 82 per cent. The highest proportion reached in individual cargoes is 100 per cent., and the lowest 28 per cent., but only in two instances does it fall below 50 per cent.

During July, eighteen trips comprised 2435 fish, the proportion of immature being 69 per cent., a diminution since the previous month, which is probably explicable by the fact that the body of the plaice on which the fishing chiefly depends had shifted from the inshore part of the grounds, which seems most frequented by young turbot.

It has been asserted that many immature brill are destroyed on the same grounds, but of this I can find no evidence. In fact, the brill seems rather scarce on the eastern side of the North Sea, and nearly all which I have seen brought in from thence have been sexually mature. Fishermen and fishmongers are apt to class turbot and brill alike in discriminating between large and small, which may account for the assertion I have alluded to. Brill of less than 15 inches reach the Grimsby market chiefly from about Mablethorpe, on the Lincolnshire coast, where they seem rather plentiful.

The common soles which are taken on the eastern grounds by our trawlers seem nowadays to consist chiefly of mature fish. One hears a great deal of the destruction of small soles in former years, but it appears that the boats at that time went much closer to the shore than they dare to go at present.

As may be supposed, young lemon soles and witches or pole dabs are not found on these grounds. The flounders there met with are mostly of fine size. A young halibut is sometimes taken, and common dabs of all sizes abound.

In the North Sea halibut are not usually caught in large numbers in the trawl, but in the spring I have occasionally seen large catches brought in. These consisted almost entirely of small fish, and, according to my information, were chiefly derived from the South-west Flat of the Great Fisher Bank. The trawlers that have visited the Iceland grounds this summer generally brought in only a few small halibuts, but the number was sometimes considerable when they had been fishing a ground known as Madam Piper's Bay, near Langenness.

* In dividing mature and immature turbot I made use of this limit of size, believing then that it represented the limit of sexual maturity in the female, which I have since found to be somewhat higher.

Considerable numbers of small round fish, chiefly haddock, skates, and rays, are taken on various North Sea grounds, but I do not propose to discuss this matter at present.

Long-lining.—Besides the larger skates, the only species which in its immature condition is a considerable sufferer from this method of fishing appears to be the halibut. I believe that not less than half the halibut which are brought ashore here fail to reach even the provisional standard of maturity which I have proposed elsewhere, but I have not determined the proportions with exactness. The smallest fish which I have seen landed by liners measured 15 inches, a size which, proportionally to that of the species, is less than that of the smallest plaice landed by trawlers from the eastern grounds. The matter can be better dealt with when more exact knowledge of the relation of size to maturity has been arrived at.

I understand that young coal-fish, in the "sillock" stage, are caught by liners in the Orkney and Shetland harbours for use as bait, but as the species is not of great value the proceeding seems perfectly justifiable.

Shrimp-trawling.—This industry is carried on by one boat of 22 tons, five from 15 to 18 tons, and nine from 8 to 11 tons, these last being known as "prawners." All carry similar gear, viz. a trawl of shrimp-mesh not exceeding 20 feet in beam. The larger boats were formerly in the habit of also carrying small fish-trawls or "sole-nets," but a bye-law of the Eastern Counties Fishery Committee now prohibits the use of fish-trawls in the Humber, and only permits the use of shrimp-trawls from the beginning of April to the end of September. No machinery exists to enforce this law, and I understand that, so far as the use of fish-trawls is concerned, it is generally evaded. However, as the fish brought to market by these boats purport to have been caught only in shrimp-trawls, they may be dealt with under this head. They consist of common soles, plaice, and flounders, with a few common dabs. Turbot, brill, and lemon sole are only rarely met with.

Soles are never brought to market in very large numbers, fifty or sixty pairs being considered a very fine haul for one boat in a night, but up to the latter part of June almost all the fish are under 12 inches, and sexually immature, whether males or females, so far as I can judge from the examination of a considerable number. Towards the end of June larger spent fish appear to find their way into the Humber from the off-shore grounds. Thus in the early part of June, of 126 fish 112 were under-sized, but on the last day of that month 242 fish, representing the catches of two boats, included 40 above 12 inches, some of them very fine fish. The smallest soles brought to market are from 6 to 7 inches long, any

smaller ones caught being promptly returned. During the succeeding months the proportion of large fish rather increases, but the smaller ones always largely predominate.

Plaice and flounders are sold together. The former, which never reach any great size during the time they remain in the Humber, are considered by the Cleethorpers, who used to monopolise the Humber fisheries, to be a distinct species, which they call flat-fish or fluke. They consider that the gelatinous egg-capsules of certain Polychætes are the spawn of these fish. As in the case of the sole, very small plaice or flounders are returned by the shrimp-trawlers to the sea. Those brought ashore measure from about 6 inches up to about 11 inches. I found a box of Humber flat-fish to contain 425 plaice, from 6 to 11 inches, averaging in length 7·71 inches, and in weight ·18 lb., and 34 flounders from 5 to 13 inches. The total amount sold in the market from the beginning of the season to the end of July appears to be something under 300 boxes, and thus not more than a steam trawler will sometimes bring in from the Dutch coast in a single trip.

Numbers of small whiting and cod are sometimes caught, especially the former. I have received 254 whiting, from $2\frac{5}{8}$ to $4\frac{15}{16}$ inches, and 16 cod, $2\frac{3}{8}$ to $3\frac{7}{8}$ inches, from one boat, but they are not usually brought ashore, though the whiting, even if immediately returned, would probably not survive.

Shore Fisheries: Stake-netting.—There are only two stake-net stations below Grimsby, viz. one at Cleethorpes and one at Humberstone. Both nets are owned by the same man, a resident of Cleethorpes, and, as I understand, have not been very productive during the present year.

The mesh is 1 inch from knot to knot, or $\frac{1}{2}$ inch square, and the nets are intended for the capture of sprats or smelts according to the season. The Cleethorpes net was only up for about a month in January and February, but the Humberstone net remained in use until April. I examined a week's catch, in the latter net, at the end of January. It consisted of a large basket of sprats, 2 to $5\frac{1}{4}$ inches, but mostly about $3\frac{1}{2}$ inches; less than half a stone of small herring, locally termed "scad," $5\frac{1}{4}$ to $7\frac{3}{4}$ inches; about 300 whiting, 4 to $7\frac{1}{2}$ inches; 14 plaice, $1\frac{3}{4}$ to $7\frac{1}{2}$ inches, and a few other fish of less important species. These were removed from the net and carted up to the house, where the saleable fish were sorted out, the rest being used for manure. Later in the season I am informed that large numbers of small cod and whiting were taken in the Humberstone net, but I had not another opportunity of inspecting the catch.

Ground-seining.—Only two ground-seines are in use at Cleethorpes, and do not appear to be often worked. Eels, smelts, and plaice

are taken in them, but only the larger plaice are kept, all small fish being allowed to escape. Thus, except that all Humber plaice are immature, there is no intentional destruction of undersized fish in this industry.

Shove-net Shrimping.—The hand shrimp-net in use along the Humber sands is a sufficiently formidable engine. It is shaped like the letter T, the cross-piece representing the beam, which is 9 feet long, with a short iron upright at each end, while the shaft, represented by the body of the letter, is somewhat shorter. The lower end of the net, either sprat or shrimp mesh, is laced to the beam and uprights, the upper end being gathered on to an iron ring, which is drawn up the shaft by means of cords passing through the handle of the latter. In this way the belly of the net is made exceedingly rigid, and its meshes are almost closed, so that shrimps, &c., slide right up it into a fine mesh bag or cod-end just below the ring.

There are a number of these nets in Cleethorpes, but most of them are not worked with any great regularity, as the incidence of the Cleethorpes "season," from Whitsuntide to September, brings other and more lucrative occupation to the owners. As a rule, however, a good many shrimpers go out every springtide, and some, engaged with pleasure-boats during the day, shove the net by night.

Great numbers of small fish are caught in these nets, and very many are undoubtedly destroyed, since the men are not always careful in sorting them out at the margin, but often carry the whole catch home; sorting by night is of course a difficult matter.

Small soles, turbot, and brill are usually promply returned if observed, and lesser weevers* enjoy an undeserved immunity, since their room is preferred to their company; but little "flat-fish," really plaice, are not held to be of much account.

The shrimps and small fish seem to accompany each other in approaching and leaving the margin, since a good haul of the former always involves a large number of the latter, and *vice versâ*. The minute metamorphosing stages of flat-fish are never found in this company, the smallest plaice and dabs which I have seen being about 1 inch long, and the smallest turbot, brill, and sole over 2 inches. As might be expected, the sizes vary with the season of the year, but not to any great extent; and the following list, representing the catch of one net for one tide about the beginning of the season (25th April), is sufficiently representative of the conditions during the spring and summer.

* Injuries from this fish are not uncommon, probably because the fishermen, in their dread of the harmless anterior dorsal fin, pay no attention to the opercular spine.

Shrimps	4 quarts.	
Common sole	4, $2\frac{3}{8}$ to $3\frac{1}{4}$	inches.
Turbot	1, $3\frac{1}{8}$	,,
Brill	2, $3\frac{5}{8}$ to $4\frac{3}{4}$	,,
Plaice	896, $1\frac{1}{2}$ to $4\frac{1}{2}$	,,
,,	12, $4\frac{3}{4}$ to 9	,,
Flounder	6, $2\frac{1}{2}$ to $4\frac{7}{8}$	,,
,,	3, 9	,,
Common dab	3, $1\frac{1}{4}$ to $1\frac{3}{4}$	,,
Smelt	5, $3\frac{1}{2}$ to $3\frac{7}{8}$	,,
,,	1, $6\frac{1}{2}$	,,
Dragonet	23, $1\frac{3}{4}$ to $2\frac{3}{4}$	,,
Gobius minutus	261	
Three-spined sticklebacks	29	

A few sand-eels, pogges, and pipe-fish.

Dabs are sometimes rather more numerous, and occasionally a number of small whiting are taken. *Cottus bubalis* and young sprats are of frequent occurrence. Turbot, brill, and sole are never much more numerous. Towards the end of the summer one or two fine soles are sometimes taken. The catch always includes a number of shore-crabs, which are promptly returned, as they damage the shrimps in the net and basket.

It will be seen that the bulk of the injury falls on the plaice, and I need not say that the annual destruction of the young of this fish must be enormous. How far the prolonged existence of an insignificant fishery, so baneful to the objects of an industry of national importance, can be justified is a question that must be discussed elsewhere.

Shrimp-seining.—The shrimp "seine" of Cleethorpes is in reality a fine-mesh trawl, with a mouth about 18 feet wide, which is kept open by means of a pole. Two short wooden beams, heavily loaded at the lower end, serve to keep the wings upright, and to separate the head and ground ropes. The whole affair is attached by the bridles to the axletrees of a small one-horse trolley, driven by the fisherman, and might be better described as a cart-trawl.

Seven such "seines" are owned in Cleethorpes, and work the same grounds as the shove-nets, and as they differ from the latter only in being rather more efficacious, and thus making larger catches both of shrimps and of small fish, they may be classed in the same category. The only notable difference is in the method of disposing of the catch which in the present instance is shot wholesale into a box on the cart, and not sorted until the fisherman gets home.

III. Remedial Measures.

It will be admitted that the continued destruction of large numbers of valuable fish before they have had a chance of reproducing their species can only result in increased deterioration of the industry, and that some measures must be taken to put a stop to it, unless we are prepared, and able, by artificial propagation to re-stock the sea as fast as we deplete it. Briefly the various proposals that have been put forward fall under three headings, viz. closure of grounds frequented by small fish, restriction of sale of undersized fish, and enlargement or alteration of mesh. We have seen that some of the smack-owners have adopted the eminently practical method of forbidding their boats to fish where they are likely to catch much small stuff; but the buyers, though as loud as any in their outcry, do not appear inclined to avail themselves of their undoubted power to check the evil. The proposals for legislative action have been so much discussed of late that I need only advert to such as affect the North Sea district.

It is a matter of common knowledge that the bulk of the destruction by deep-sea trawlers takes place on the eastern grounds, to which I have alluded elsewhere; and since these lie wholly or in part outside the three-mile limit, it has been proposed that they shall be closed to trawling by international agreement. Whether such agreement could ever be arrived at is questionable; and if it were, it is not likely that the ensuing legislation could be easily enforced. The great extent of the grounds would involve an enormous and costly Marine Police force, of mixed nationality; and even were such a body much more efficient than one has any reason to expect, there might be considerable difficulty in adequately watching grounds which extend in some cases over fifty miles from shore. Indeed, on our own coasts and elsewhere the success with which legislation limited to the territorial area has hitherto been enforced is hardly such as to encourage us to extend the principle to the open sea.

The various standards of size which have been advocated, in proposals for prohibiting the sale or possession of undersized fish, differ according as the subject has been treated with regard to the marketable qualities of the fish, or to its powers of reproduction; and it may be assumed, I suppose, without argument that the latter is the more rational method of treatment. Still it may be as well to recapitulate the sizes proposed at the Fishery Conference at Fishmongers' Hall last February, since they may be taken to represent the most recent trade opinion on the subject.

They are for turbot and brill 12 inches, for soles and lemon sole (*Pleuronectes microcephalus*) 10 inches, and for plaice 11 inches. How far they fall short of the biological limits, at least for the North Sea district, can be judged by comparing them with the table of sizes on p. 384; and, indeed, I may remark that the prohibition of the sale of turbot and brill under 12 inches in length is rather a work of supererogation, since the number of smaller fish of these species that come to market, at all events at Grimsby, is utterly insignificant.

The benefit to be expected from any measure of prohibition depends of course on the vitality of the fish, and it is very generally asserted that the bulk of the small fish trawled on these eastern grounds would not survive if returned. My own experience leads me to believe that this view is correct* so long as the present system of long hauls is maintained. Hence we must seek for such a limit as will render the grounds most frequented by these small fish unprofitable to the fisherman (since any less limit would only involve an infinitely greater waste than takes place at present), and in doing so it is necessary to glance at the general conditions of this fishery.

Exclusive of less important forms, the species chiefly met with are plaice, turbot, and soles. The plaice, on most grounds, do not exceed a length of 15 inches, and are mostly less than 13 inches in length. The turbot are fairly abundant, but, as I have already shown, almost all immature; soles are scarce. It is only the certainty of being able to fill up with small plaice that induces the fisherman to cross to the eastern side, since the soles and turbot would not nearly pay his expenses by themselves. Now I am confident that if the Conference limit of 11 inches for plaice were enforced, there would still be enough saleable fish left to make the grounds worth visiting, whereas if it were raised to 15 or even 14 inches the grounds would assuredly be left alone; and although such would be below the biological limit, I believe the practical closing to our huge fleets of such a magnificent nursery for young plaice would be in itself a sufficient protection for the species. Certain rough patches of ground, practically surrounded by areas yielding only small fish, abound with only large fish; these would still be accessible to fishermen, whereas in any scheme of geographical restriction it would hardly be possible to exempt them. Moreover the restriction of size would probably do away with the destruction of small plaice by shrimp- or sole-trawls, since the fish are not injured

* Owing to the great mass of fish caught in a single haul, I consider it quite possible to hold this view without throwing any doubt on the value of the results obtained by my friend Dr. Fulton in his experiments on the vitality of trawled fish (Report S. F. B., 1891).

by being caught in these nets, and if unsaleable* would probably be returned.

For turbot, brill, and sole I would advocate the adoption of the biological standards. They are all rather hardy forms, and it appears that immature brill and such immature turbot as are found on our own coasts are chiefly caught on certain banks where the intricate nature of the ground renders short hauls a necessity, so that they could be returned to the sea in good condition, as indeed the smaller of them usually are at present by many fishermen. With regard to soles, I do not think that many undersized fish are caught by deep-sea trawlers,† and the substitution of a size limit for the present prohibition of the use of a fish-trawl in the Humber would do away with the anomaly of a law which is not enforced. There is a strong feeling amongst inshore fishermen that the bye-law alluded to is unequal in its operation, since it offers no check to the destruction of small fish on off-shore grounds, only accessible to large boats. Hence a regulation as to the size of fish landed is perhaps preferable to one based solely on territorial conditions somewhat imperfectly understood.

An objection which I have heard urged against any scheme for keeping our trawlers off the eastern grounds is that the summer sole trade in the North Sea would thereby be left entirely in the hands of foreigners. I think that this is, perhaps, rather overstating the case, but anyhow I cannot see that it furnishes any excuse for the present enormous destruction of small plaice and turbot, whilst it is at least possible that the abstention of our own fleet from these grounds in the summer would result in a corresponding increase in the number of soles in the localities where that species congregates in the winter months. I have no knowledge of the migrations of soles, but the Great Silver Pit is equidistant from the Humber and the nearest eastern ground, and as it is the nearest point at which similar physical conditions can be attained, it does not seem improbable that the winter supply of soles in the Pit is in part recruited from the east side of the North Sea.

Another objection is that boats of British nationality are not the only ones engaged in the small fish trade, and it is true that during the summer months a number of German, Dutch, and Danish boats are occupied in catching small plaice. But they are all of small tonnage, some of them only open boats ; and I understand that from

* The possession, as well as the sale, should be prohibited, to guard against the possible danger of small fish being utilised as manure when the fisherman is also a farmer in a small way.

† The small soles caught on the Dogger and on the Dowsing are really solanettes (*Solea minuta*).

the manner in which the trawl is handled by German and Danish boats no injury is done to the unmarketable fish, whilst the saleable part of the catch appears to be exported chiefly to London. Hence the proposed measures of prohibition would give no advantage to these nations. The German steam trawlers, according to my information, do not molest the small plaice at all. Of the proceedings of the Dutch bombs I have little knowledge, but from the small size of their gear, their share in the destruction cannot be a very large one. Foreign-caught fish, except Norwegian salmon and mackerel and Dutch soles, including only a small percentage of undersized fish, rarely come to the Grimsby market, but on two occasions large consignments of small plaice, comprising, as I compute, some 31,000 fish, were sent from Denmark, and recently a consignment of turbot has arrived from Norway. These last fish were about 300 in number, all undersized, viz. from 9½ to 17 inches, whilst 4 were only from 8 to 9 inches. This is the only instance which has come under my notice of any considerable number of turbot less than 12 inches being present in the market, and, as we have seen, our own fishermen were not concerned in it.

The last and perhaps the most important objection arises from the difficulty in allowing for that variation in the size of fish of the same species on different parts of our own coast to which Mr. Calderwood alluded in the last number of this Journal, p. 208. The impossibility of utilising a uniform size limit for all districts is sufficiently exemplified by the limit of 11 inches for the plaice proposed by the Conference of last February, which was the result of a compromise between the trade representatives of the North Sea and south and west coast districts. While perhaps unnecessarily high for the Plymouth district, we have seen that it is altogether too small for the North Sea. The difficulty of having different limits, of local application, will only be felt at such a central port or market as London, to which fish are brought, whether by rail or sea, from all districts, but with proper organisation the obstacle does not seem insuperable. It is conceivable that the law might be evaded by running cutters from boats fishing in one district to the parts of another, where the limit was lower, but it is little likely that the firms which are in a position to undertake them, would lend themselves to such operations. There is not the slightest reason to apprehend a general conspiracy of evasion amongst the fishermen, and the boats which respected the law would form a more efficient police than all the cruisers in the navy, so far as one may judge by the conditions on the Scotch coast, where convictions of trawlers for infringement of the territorial restriction are frequently secured by the evidence of local line fishermen.

I must leave to others, who are acquainted with the local conditions, to decide whether the imposition of a size limit is desirable in other districts, but for the North Sea I have not the slightest hesitation in recommending this method of legislation, in the terms I have proposed above, as cheaper and likely to be infinitely more efficacious than any other that can be devised in maintaining the supply of the more important kinds of flat-fish. I need hardly observe that its application to the halibut, which is chiefly a line fish, could not fail to be beneficial to that species, since there is no question but that fish caught on the hook will usually survive if returned;* but I do not think that the limit need be as high as the biological one, owing to the difference in the conditions of the trawl and line fisheries.

I am not prepared to enter at present into the question of mesh legislation, beyond pointing out that it appears to be the only method by which the destruction of immature round fish, notably haddock and whiting, can be checked, since these species are fatally injured by being caught in the trawl, and would not survive if returned. Any great enlargement of the mesh does not appear advisable, since it would afford an opportunity of escape to the mature sole, of which that active species would be extremely likely to avail itself. The remedy seems to lie rather in an alteration of the arrangement of the meshes in the cod-ends, so as to prevent them from closing. On this subject I have been making investigations, but they are not yet sufficiently complete to yield reliable deductions. It is sufficiently evident, as has often been pointed out, that the great breadth of some of the flat-fish render it impossible to deal with the whole question by restrictions of mesh alone.

The last matter with which I have to deal is the destruction of very small fish by shove-net and shrimp "seines." If it were only possible to induce the men to cull out the small fish in the water they would do no harm at all, and practically I suppose that, as matters are, they do not greatly injure any species of known value except the plaice, although the small number of sole, turbot, and brill destroyed may represent, from the relative scarcity of these species, a more considerable injury than one would suppose. When fishing by day the shove-net men usually return the fish to the sea, but by night this is impossible, and the seine men do not seem to make any effort in that direction either by day or night.

It is a difficult question to deal with, since the shrimp appears to be almost a necessity to some people; at the same time the small plaice which are destroyed must represent an infinitely greater value than the shrimps. If hatcheries were established, and young turbot,

* Except fish with air-bladders, caught at considerable depths.

brill, sole, and plaice were enlarged after they had been reared through the delicate larval and metamorphosing stages, it is reasonable to suppose that they would be conveyed or would find their way to the sandy margins, which seem best adapted to the succeeding stages of their life-history, only to fall into the net of the shrimper.

I should say that to prohibit the use of any sort of shore shrimp-net during night-time would be a beneficial measure, but there is perhaps sufficient reason for abolishing the industry altogether. Those engaged in it might be sufficiently compensated at a moderate expenditure, if indeed it be not contrary to public policy to admit the existence of a vested interest in an occupation which is essentially injurious to industries affecting a much greater section of the community.

Monthly Reports on the Fishing in the Neighbourhood of Plymouth.

By

W. L. Calderwood,
Director of the Laboratory of the Marine Biological Association.

II.

The four charts published in this number, being for the months of May, June, July, and August, form a continuation of the series of reports commenced in the last number (vol. ii, No. 3) and are intended to show the position of the fishing fleets.

The same symbols have been used, which, for convenience, are again given below.

I do not propose to attempt a full description of each month's fishing, but rather let the charts explain themselves, giving only a few necessary notes on the dates of the movements of shoals, which may be of use on a subsequent occasion.

May.—The mackerel fishing marked on this chart only lasted till the 7th of the month. The shoals were travelling rapidly towards the westward, and on the 10th were found 20 miles south-west of the Eddystone. On the 14th all the fleet left Plymouth and proceeded to St. Ives, from which port large catches were obtained.

The whiting fishing was very poor, and the boats changed ground so frequently that a proper estimate of their position became difficult.

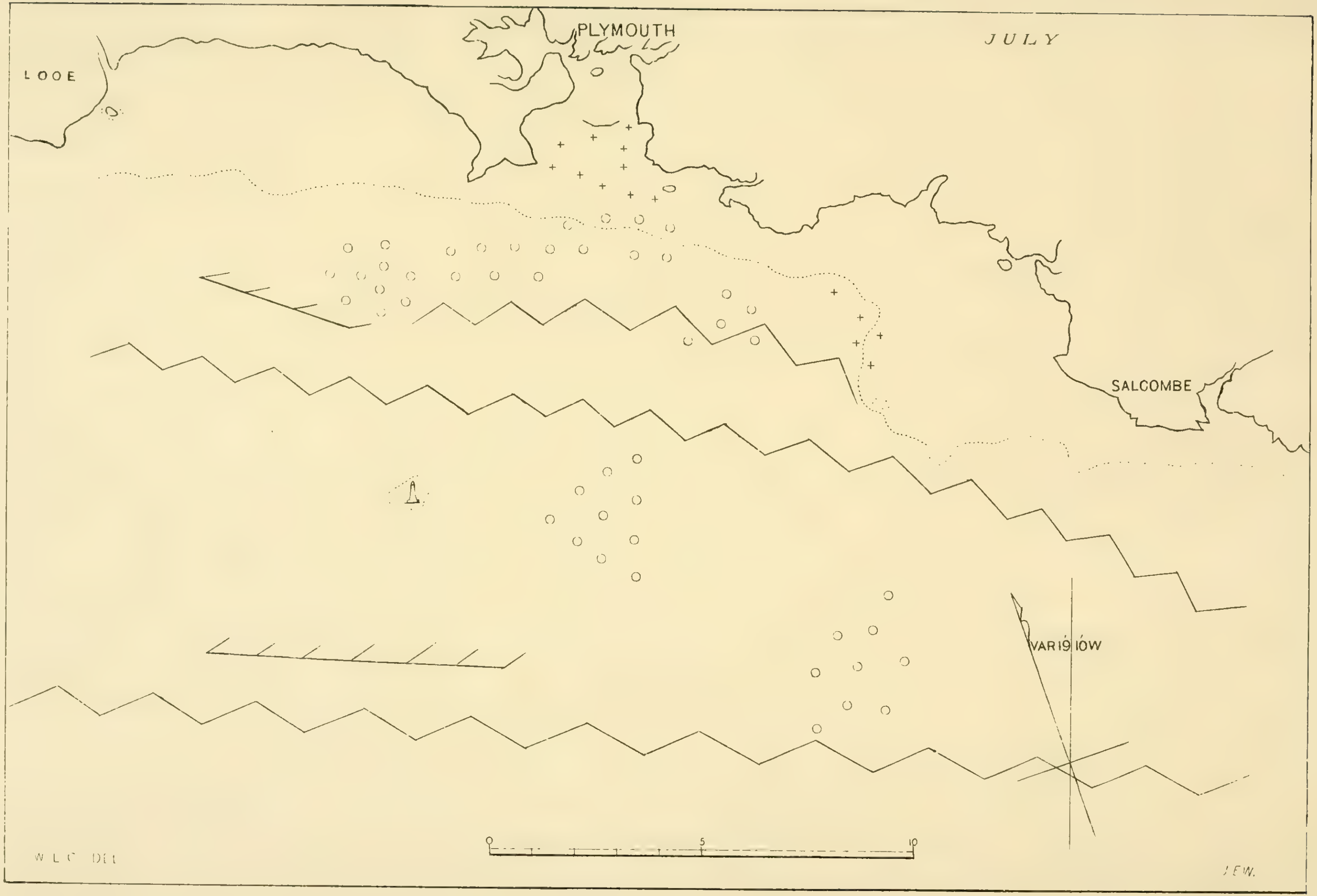
The majority of trawlers worked much more to the westward than can be shown on the chart, the positions shown being only taken up on the dates placed against them.

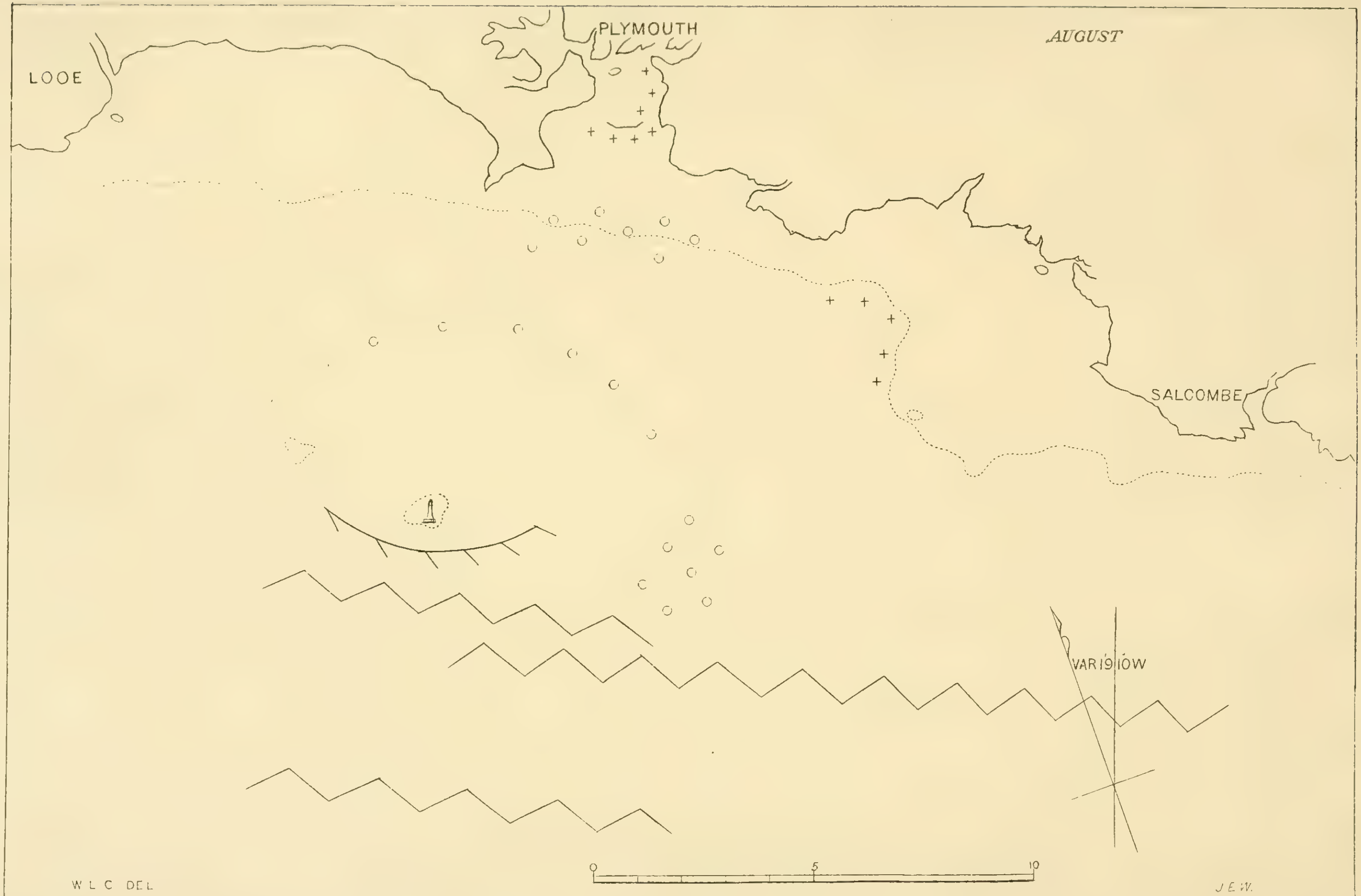
The pilchard fishing marked in Whitsand Bay occurred on the 22nd inst.

June.—The mackerel are in this chart marked as being close inshore, and extending from the Mewstone to the Eddystone. The fish occurred in this position for only a short time about the 10th ;


MAY
PLYMOUTH
LOOE
SALCOMBE
VAR 19 10W
0
5
10
W L C DEL
J.E.WOOD PLYMOUTH


JUNE
LOOE
PLYMOUTH
SALCOMBE
VARI9 10W
0
5
10
W L C DFL
J.E.W.


JULY
LOOE
PLYMOUTH
SALCOMBE
VAR 19 10W
0
5
10
W L C DEL
J.E.W.


AUGUST
LOOE
PLYMOUTH
SALCOMBE
VAR 19 10 W
0
5
10
W L C DEL
J.E.W.

the majority of the boats were fishing 40, 60, and 70 miles south and west of the Eddystone. A large number of the whiting boats, on account of their ill-luck, took to mackerel fishing. The long-liners are not marked. Only one boat was at work from 10 to 25 miles south-west of Eddystone.

July.—The mackerel boats are still far south of Eddystone (35 to 75 miles).

The whiting boats are still a good deal scattered, and more trawlers are working in the area included by the charts.

All trawlers not working on the "home grounds" (about half the fleet) are fishing the Bristol Channel.

Long-liners, besides those marked on the chart, are at work 10 to 20 miles south of Eddystone.

August.—The long-liners marked here just south of the Eddystone occupied this ground only during the last week of the month. During the early part they were fishing off Bolt Head and Prawl Point.

The mackerel fishing is now drawing to a close, the fish going further and further south. By the middle of the month they were captured from 60 to 70 miles south of Eddystone, some of the boats being within sight of the French lights. By the 20th the fishing ceased for the season. Trawlers still working largely on the "home grounds."

Key to Symbols used in Monthly Fishery Charts.

////////	=	position of herring boats.	
⋰⋰⋰⋰⋰⋰⋰⋰	=	,,	of mackerel boats.
\\\\\\\\	=	,,	of pilchard boats.
/\/\/\	=	,,	of trawlers.
o o o o	=	,,	of whiting boats.
+ + + +	=	,,	of crab and lobster boats.

NOTES AND MEMORANDA.

Polyprion cernium, Val.—Two specimens of this fish, the stone basse or wreck-fish, were obtained on September 21st. The one was sent by Mr. Dunn, of Mevagissey, the other captured by hook and line off Plymouth. The first specimen measured 19½ inches, the second 20½ inches.

It is singular that two of these fishes, which are by no means common, should have occurred at the same time. If the statement to the effect that these fishes are in the habit of following wreckage be true, it may be that several have arrived off our coast in this manner. The fish is common at Madeira.—W. L. C.

Scomber scomber, Linn (the **Mackerel**).—In sorting some young fish, chiefly the "mackerel midges" of *Motella tricirrata* which were taken at the surface at the end of July by Mr. F. Klotz, of the s.s. "Dominican," I found three specimens which prove to belong to this species, of which the later larval stages had not hitherto been recognised.

The total lengths are respectively 13·75, 16·5, and 18·5 mm. In the largest specimen the head and abdomen are about equal in length, and together a little longer than the caudal region, exclusive of the caudal fin. The eye and the snout are each about one third, and the greatest height of the body is about three quarters of the length of the head. The general shape of the fish is very much the same as that of the young Temnodon figured by Agassiz (*Young Stages of Osseous Fishes*, Proc. Am. Ac. Art. Sci., vol. xiv, 1878, pl. ii, fig. 5), but the upper jaw is slightly the longer. The caudal, which is completely metamorphosed, is separate, and appears to be notched in a similar manner, but is rather damaged in all my specimens. The same interval occurs between the anus and the anterior anal rays as in Temnodon. The differences in the rays of the permanent dorsal and anal fins, which are visible in the persisting embryonic fin-membrane of those regions, are also those of the adults. In my examples the first dorsal occupies the adult position, separated by a wide interval of embryonic membrane from the second. The ridges from which spring the rays of the continuous anterior parts of the permanent second dorsal and anal fins are continued

backwards towards the caudal peduncle, and are strongly notched at intervals. Each notch marks the site of one of the finlets of the adult, but at the present stage it is occupied only by a single stout ray. There are five such isolated rays in the anal fin of the specimen of 16·5 mm. (in which the fins are the most expanded), thus corresponding in number to the finlets of the adult.

The colours in spirit specimens are as follows :—In the largest specimen the eye, gill-cover, and sides of the abdomen are silvery. There is a large deep black patch on the top of the head, due to pigment in the pia mater of the optic lobes ; some smaller black patches occur on the snout, jaws, and isthmus. There is a dark line along the dorsum and at the base of the anal fin. From these lines dark pigment dots extend along the myomeres to the lateral line, the region of which is thickly powdered with such dots. The two smaller specimens differ only in exhibiting less pigment on the sides of the body, very little being present in the smallest, in which also the silvery matter is so little developed as to allow the black peritoneal pigment of the abdominal roof to be clearly visible.

In the early part of the same month I took at the surface a few much smaller fish, to which at the time I devoted little attention beyond noting the light blue colour of the eye, and the presence of yellow amongst the black pigment of the top of the head and abdomen. They are all rather badly injured, but the larger amongst them, about 9·5 mm., approach the smallest of the series previously described in the shape of the head and the distribution of black pigment. The permanent dorsal and anal fins are not yet represented, so afford no assistance. The differences in the proportions of the pre- and post-anal regions are not more than might be expected in the same species at such different stages. The smallest specimen sufficiently well preserved to be of any use measures 7 mm., and while certainly belonging to the same species as that of 9·5 mm., it also approaches the oldest stage to which I have been able to rear mackerel larvæ from the egg. The largest of such measures 4·88 mm., and the black pigment differs from that of the tow-net specimens only in quantity, and not in distribution. The large light blue eye, and the presence of yellow pigment in the regions indicated above, are features which both series possess in common.

Though, owing to the bad condition of the smaller tow-net specimens, absolute proof is wanting, I think it very probable that they are really mackerel. They were taken on the 8th July, about twenty miles N.N.E. (magnetic) of the Horn Reef Light-vessel, coast of Jutland. The locality and date of the larger specimens are mentioned elsewhere by Mr. Cunningham.—E. W. L. H.

Year-old Pilchards.—Since the last date mentioned in my paper in the previous number, our anchovy-nets have only been shot once, on April 23rd, when only eight pilchards were taken, all except one over 19 cm. ($7\frac{1}{2}$ inches) in length. But I was informed by W. Roach that a large number of sardine-sized pilchards were taken with a mackerel seine on May 23rd and June 8th in Whitsand Bay. We received one specimen of the former capture—it was 14·9 cm. long; and six specimens of the latter, which measured 15·4 to 16·6 cm.

Some of these yearling fish were said to have been sent to the Mevagissey factory to be tinned. Pilchard ova have been very abunudant in the tow-nets worked a few miles outside the Breakwater this September.—J. T. C.

Muggiæa atlantica.—Since the publication of my account of this Siphonophore in the previous number of the Journal I have obtained evidence that it appears annually in abundance in the neighbourhood of Plymouth South. I first noticed it this year in the produce of a somewhat large-meshed tow-net (mosquito netting) worked at a depth of about 20 fathoms, on the east side of the Eddystone, on August 25th; and soon after it appeared among the plankton collected a few miles outside Plymouth Breakwater. Towards the middle of September it became very abundant, and was secured in perfect condition and in various stages.

At the present date (September 26th) it still occurs, but its numbers have much decreased. Mr. Rupert Vallentin, of Falmouth, has drawn my attention to the fact that as long ago as 1849 a pelagic animal was described and figured by Charles Wm. Peach in the Twenty-ninth Report of the Royal Institution of Cornwall, which can be recognised as identical with *Muggiæa atlantica.* The title of the paper in which the description occurs is *Observations on the Luminosity of the Sea, with descriptions of several of the objects which cause it, some new to the British coasts.* The organisms I refer to are described in this paper under the name Diphydiæ, in which family is included also a Protozoan of the family Tintinnidæ. The description of the Siphonophore is by no means correct, the polypes of the eudoxomes being mistaken for ova; but the figures, though very rough and inaccurate, leave no doubt in my opinion that *Muggiæa* was the form which Peach had under observation. A remarkable feature of the paper is the record it gives of the pelagic organisms observed in successive months of the year in the course of four years, 1846 to 1849. In this record we find that in 1849, the "Diphydiæ" were observed for the first time on July 1st, and on July 20th occurred in thousands: in October they were also noticed. They are not mentioned

in the observations of other years, but these were much less numerous, and the omission does not prove that *Muggiæa* did not occur in those years. Peach's collections were made in Fowey Harbour and just outside of it.—J. T. C.

Hippoglossus vulgaris, Linn. (the Halibut).—On the 30th April I succeeded in pressing some apparently ripe ova from a female halibut in the market. I had no opportunity of examining the ovary, but external pressure caused the extrusion through the genital orifice of a quantity of yellowish viscous putrid liquor, amongst which were a quantity of collapsed zonæ radiatæ, and the ripe ova referred to. The fish was dead, and appeared very stale. All the ova were dead and more or less decomposed, but some were sufficiently fresh to illustrate the living condition.

The diameter varies from 3·070 to 3·818 in my specimens; the yolk conforms to the condition met with in other dextral Pleuronectids, being colourless, translucent, and homogeneous, and destitute of an oil-globule. The zona is thin, measuring ·03 to ·04 mm. in optical section, and remarkably delicate and flexible.

Externally it is finely dotted; internally are a number of slight ridges, which give the whole structure the appearance of being irregularly scribbled with fine striæ. Laminæ are clearly visible, but radial pores cannot be seen in optical section in fresh preparations.

The ova are evidently pelagic, and the extreme delicacy and flexibility of the zona (which is such as to render it difficult to pick up an egg with the forceps without causing it to collapse) suggests that a large perivitelline space may be formed under natural conditions, since this takes place in the long rough dab (*Hippoglossoides limandoides*), which is the nearest relative of the form before us, and in which the conditions of the zona are very similar.

Ripe but unfertilized ova were obtained by Prof. McIntosh shortly afterwards, and from a brief note which he has published (Ann. Mag. Nat. Hist., July, 1892) it appears that some of them were a little larger than the largest of mine.

It is evident that the halibut's ova are not commonly to be met with along our coasts, since such relatively enormous structures could not fail to have attracted attention in the tow-nets.—E. W. L. H.

Rhombus maximus, Linn. (the Turbot).—I am not aware that the ova of this important species have ever been described in sufficient detail to ensure their recognition if met with in the contents of the tow-net, nor is there any description whatever of the embryonic and larval stages.

Ova taken from a number of females at Grimsby and on the North Sea showed but little variation, the usual diameter being 1·01 mm., and the extreme sizes ·99 and 1·06 mm. The oil-globule is nearly always ·21 mm., but may be as small as ·18 mm. Thus the ova of ·77 mm., supposed by Wenchebach to be ripe, must have been unusually small if they were really in that condition.

The yolk is colourless and homogeneous, but the oil-globule in recently spawned ova has a very pale ochreish tint. This is hardly visible unless a great number of ova are together in a vessel, when the globules impart their colour to the whole mass. Under similar conditions the ova of the brill (*R. bevis*) exhibit the colour of a very weak solution of ink, also due to the oil-globules.

The zona exhibits much the same characters as that of the brill, but the markings due to elevations of the internal surface are less closely set, forming a rather open network, of no regular pattern. They are retained, at all events in artificially fertilized examples, until a late period of development *in ovo*. The whole structure is less delicate than that of the megrim (*Rhombus megastoma*).

Fertilization does not appear to affect the dimensions; the perivitelline space is small. Unfertilized ova seem to retain their vitality for an unusually long period; some were successfully fertilized 17 hours after they were taken from the parents. Sir James Maitland's experiments with the milt of Salmonidæ will be remembered in this connection.

I was only successful in hatching one lot of ova. The larvæ began to emerge on the seventh day, but most emerged on the ninth day. None lived for more than a few days after hatching. They were very likely more feeble than those hatched under natural conditions, although as the attempt to rear them was made at sea, with plenty of good water available, I do not know why they should have suffered.

The newly hatched larva measures only 2·14 mm., of which considerably more than half is occupied by the yolk. The oil-globule is ventral in position instead of posterior, as seems to be the case in the brill. The marginal fins are narrow, the pectorals remote from the eye, and the whole larva appears less advanced than is usual in Pleuronectids at the time of hatching.

Both black and coloured chromatophores are present, the latter being the most numerous. In the newly hatched larva they are simple and almost entirely to the head, trunk, and tail, and to the periblast internal to the oil-globule; but they soon become dendritic and spread all over the skin, except at the caudal extremity, being less abundant than elsewhere on the yolk-sac. When first visible the coloured pigment is pale yellow, but by the time of

hatching it has deepened to a very red orange by reflected, bright red rust-colour by transmitted light. A day or two after hatching it is an intense fiery orange by reflected, inclining somewhat to crimson by transmitted light. This coloration is more closely approached by the hybrid turbot and brill larvæ, described by Professor McIntosh (Reps. S. F. B., 1891), than by any other British form with which I am acquainted. It appears from subsequent observations by the same author (Ann. and Mag. Nat. Hist., July, 1892) that the true-bred brill larva does not materially differ from the hybrid.

It had been surmised by Professor McIntosh and myself, in the absence of any exact information on these stages of the turbot, that a minute Pleuronectid ovum and larva, the species F of McIntosh and Prince (op. cit.), might prove to belong to that form. The present observations show that this is not the case, since, apart from the differences in dimensions of the ovum, the pigmentation is entirely different, and the turbot at no stage exhibits the peculiar reticulate structure of the epidermis which always characterises species F. Hence the affinities of the latter must be sought elsewhere, probably amongst the top-knots.

A remarkable tendency was observed, which may render the artificial culture of the turbot a matter of difficulty.

In the several clutches which I fertilized the ova sank to the bottom at from two to seven days after fertilization. They did not appear unhealthy, and continued to develop as well as such as remained floating, but it was impossible to separate them from the dead ova, which always form an unpleasantly large item in the contents of a hatching jar.

The same behaviour was exhibited by four different clutches of ova fertilized for me by fishermen at sea: in one case I am informed that the ova sunk after only a few hours, though at the end of two days they still looked healthy; they were then thrown away, on the ground that if they were not dead they ought to be.

Thus we have pretty strong evidence that there is a general tendency in the turbot's egg to sink sooner or later after fertilization, and we know from Raffaele that this is a regular feature in the development *in ovo* of *Trachinus;* it happens also occasionally in the gurnard and some other forms.

I imagine that the successful culture of a pelagic ovum which assumes a demersal nature at an uncertain period will be difficult.

Later Stages.—Like the ova and larvæ, the younger metamorphosing stages seem to have escaped the notice of naturalists. In fact, the earliest examples which could indubitably be referred to this species are those enumerated by Mr. Cunningham in an earlier

number of this Journal (N. S., No. 2, p. 105). The smallest of these meausres 15 mm. The series of younger examples, doubtfully referred by Professor McIntosh and Prince (op. cit., pp. 845—847) to this species, is acknowledged by these authors to be incomplete, and in the light of more recent observations it seems certain that some of them are not turbot.

It has recently been my good fortune to obtain such a series of specimens, ranging from 5·50 to 16·25 mm., as serves in great measure to fill up the existing gap in the life history. They were taken at the surface in various parts of the North Sea, partly by myself and partly by Mr. F. Klotz, skipper of the steam trawler "Dominican," to whom I am also indebted for much other valuable material. The localities and dates of capture are enumerated elsewhere by Mr. Cunningham, so need not be recapitulated here.

Reserving for the present a detailed and illustrated description, I think the following characters will serve to ensure the recognition of similar examples.

All specimens which I have examined possess a well-developed air-bladder. The snout is short and obtuse, less than the diameter of the eye in smaller examples, about equal to it in examples of 11 mm., and becoming slightly greater in larger specimens. The articular region is more or less prominent at all stages. In the smallest example the tail is narrow and the abdomen prominent, the body slightly flattened, and the eyes practically symmetrical. At about 7 mm. the asymmetry becomes better marked. By the deepening of the caudal region the prominence of the abdomen has disappeared. The greatest height of the body without fins is nearly a third of the total length, and occurs in the region of the clavicle. The marginal fins are still very narrow. At about 11 mm. the contour is roughly fusiform; the greatest height, about half the total length without the caudal fin, is situated just behind the anus, or midway between the snout and the origin of the caudal fin. The marginal fins are much broader and supported by rays. The right eye is just beginning to show above the ridge in a specimen of 13·5 mm. In the largest example about half of the right eye is visible from the left side, and the greatest height of the body is nearly two thirds of the total length without the caudal fin. The fin-ray formula, in specimens in which it is ascertainable, agrees sufficiently with that of the adult.

The most peculiar feature of these young turbot is the cephalic armature. In its maximum development it may be described as follows:—A pectinate ossific ridge overhangs the postero-dorsal region of each eye; a short ridge, bearing stout, postero-ventrally directed and somewhat curved spines, occurs on the articular region

of the mandible, in such a position as to be almost masked by the maxilla when the mouth is closed. The pre-operculum bears short, outwardly directed spines along the entire length of its keel, and longer backwardly directed spines are present on its posterior portion, the margin of which is also serrated. The free edges of the sub-operculum and inter-operculum are strongly serrated near their union.

The spines above the eye seem the earliest developed, as they are present even in my smallest example. The ridge on which they are borne seems to represent the outer edge of the frontal scuta, which must ossify at an earlier period than the rest of that structure. The ridges of each side become opposed in the process of metamorphosis, and persist in the adult, but they lose their prominence and the serration of the edges before the oldest stage in my series is reached. The mandibular armature is early formed and early lost, but its (apparent) position is marked in the adult by the strong lateral keel of the articular. The opercular spines do not seem to be present in the smallest examples, in which the scutes of this region are probably not yet ossified. They reach their maximum development in specimens of about 10 or 11 mm., and thereafter tend to disappear, doubtless by the growth of additional bony matter around them. The serrations of the sub-operculum and inter-operculum persist longer than the rest, and are visible, though very blunt, in my largest example. Indentations exist in the margin of these scutes even in a specimen of 25 mm. kindly sent to me from Plymouth, and very faint indications of the same can be made out in a specimen of 175 mm., though none are perceptible in adult specimens. At no stage of which I have any knowledge is there any spinous process or processes in the region of the otocyst, and this serves to distinguish young turbot from certain of the small forms attributed by McIntosh and Prince (loc. cit.) to this species, and also from some remarkable Pleuronectid larvæ which were obtained during the survey on the west coast of Ireland. Since the smaller larvæ briefly described by the Scotch authors are said to agree in pigmentation with those which exhibit spines on the otocyst, it seems very unlikely that any of them are turbot, and therefore the North Sea series which I have described above are probably the first recorded examples at those sizes.

It is interesting to find a Pleuronectid passing through a stage in which its cephalic armature is as powerful as, and for the most part homologous with, that of a Percoid or Scorpænoid, though I cannot call to mind any form in which the mandibular spines of the young turbot are represented. Amongst Acanthopterygians we are familiar with instances in which, while the head is practically

unarmed in the adult, it is well armed in the young (*e. g. Naucrates*), and it is frequently the case that the armature of this region is more powerful in the young than in the adult. If protective in function it is easy to understand that the spines of the turbot would only be required as long as the pelagic habit is maintained, but I think it is not less probable that their significance is simply ancestral.—E. W. L. H.

ERRATUM.

N. S., Vol. II, No. 3, p. 282.

Under *Gadus esmarkii,* for "30 to 50 fathoms cable" read "30 to 50 fathoms ca." (circa).

INDEX.

D.

E.

F.

N.

O.

P.

V.

W.

X.

Y.

Z.

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